



Cooking time but not cooking method affects children's acceptance of *Brassica* vegetables

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ABSTRACT

The home environment potentially presents a simple means to increase acceptance of sensory properties of vegetables by preparation. This research investigated how preparation can effectively impact upon children's acceptance for vegetables. Five- and six-year old children ($n = 82$, balanced for vegetable consumption) tasted and evaluated two *Brassica* vegetables, broccoli and cauliflower, each prepared in six different ways via variations in cooking method (boiling versus steaming) and cooking time (3 levels, ranging from 2 to 14 min). Children rated samples for liking and a trained descriptive panel assessed the samples' sensory properties. Across vegetable types, medium cooking times were liked more than short and long cooking times ($p < 0.0001$), and these samples were medium *firm* and *cohesive*, with a balance of *green* and *cooked flavour* notes. Boiled samples were less intense in flavour and taste than steamed samples, but overall did not differ in acceptance. Significant interactions were found. Cooking method played a role in acceptance of broccoli but not cauliflower, with medium steamed broccoli liked the most. There was no difference in acceptance between low and high vegetable consumers, although high vegetable consumers were more discriminating in acceptance for cauliflower. In conclusion, children's acceptance of *Brassica* vegetables may be altered by preparation. There may be advantage in promoting steaming of *Brassica* vegetables to children, as they do not object to the flavour, and steaming is nutritionally preferable to boiling. Very short cooking times lead to an undesirable sensory profile and should be avoided. Recommendations are applicable to children regardless of their vegetable intake.

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1. Introduction

A high intake of *Brassica* (*B. oleracea*) vegetables, such as broccoli and cauliflower, reduces the risk of several types of cancer and cardiovascular disease (Soengas, Sotelo, Velasco, & Cartea, 2011). There is evidence that sensory properties are a key determinant to *Brassica* consumption (Cox, Melo, Zabararas, & Delahunty, 2012). This is particularly relevant for children, who are not receptive to health messages (Wardle & Huon, 2000), and for whom sensory preferences are a key driver to food consumption (Bere & Klepp, 2005; Rasmussen et al., 2006; Ton Nu, MacLeod, & Barthelmy, 1996).

Preparation affects children's acceptance for vegetables (Baranowski et al., 1993; Baxter, Jack, & Schröder, 1998; Poelman & Delahunty, 2011; Szczesniak, 1972; Zeinstra, Koelen, Kok, & de Graaf, 2010). Sensory studies with various vegetables have shown that children prefer preparation methods using water (i.e. boiling or steaming) to preparation methods using heat with or without oil

(i.e. baking, stir frying or grilling), which was related to a dislike of brown colour, browned odour and browned flavour (Poelman & Delahunty, 2011; Zeinstra et al., 2010).

There is some evidence that adults prefer steamed to boiled vegetables (Rennie & Wise, 2010; Zeinstra et al., 2010), but little is known about children's preferences in this regard. Zeinstra et al. (2010) found that steamed and boiled carrots and beans were equally liked by 4–12 year old children. To our knowledge, no studies have investigated children's preferences for *Brassica* vegetables in relation to boiling and steaming.

Steaming requires a longer cooking time than boiling to reach a similar texture (Galgano, Favati, Caruso, Pietrafesa, & Natella, 2007; Pellegrini et al., 2010). Controlled for texture differences, boiled vegetables are less intense in flavour than steamed vegetables (Nunn, Giraud, Parkhurst, Hamouz, & Driskell, 2006; Schnepf & Driskell, 1994), due to leaching out of water soluble flavour compounds (Nunn et al., 2006; Song & Thornalley, 2007; Yuan, Sun, Yuan, & Wang, 2009). Cooking time impacts on sensory properties of *Brassica* vegetables also. Increased cooking leads to decreased firmness and associated texture attributes (Poelman & Delahunty, 2011), can lead to flavour loss (Schnepf & Driskell, 1994), and affects colour (van Boekel, 1999). Children reportedly like crunchy,

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hard textures (Baxter et al., 1998; Szczesniak, 1972; Zeinstra et al., 2010), whereas flavour is assumed to be a barrier to consumption (Baxter & Schroder, 1997; Baxter, Schröder, & Bower, 1999). Therefore children may prefer the relative blandness of boiled to steamed vegetables, and may prefer shorter to longer cooking times.

From a nutritional perspective, shorter cooking times have benefits over longer cooking times, primarily for boiling, where two-third losses in vitamin C and phenolics were observed after 5 min boiling (Zhang & Hamauzu, 2004). Steaming of *Brassica* vegetables has advantages over boiling, in retention of water soluble nutrients such as vitamin C (Galgano et al., 2007; Miglio, Chiavaro, Visconti, Fogliano, & Pellegrini, 2007; Pellegrini et al., 2010; Schnepf & Driskell, 1994; Yuan et al., 2009), and glucosinolates, which also leach into cooking water (Miglio et al., 2007; Pellegrini et al., 2010; Song & Thornalley, 2007; Yuan et al., 2009). There is also evidence that steaming retains or even increases carotenoids, a fat soluble compound (Miglio et al., 2007; Pellegrini et al., 2010; Yuan et al., 2009). Benefits are reflected in Australian government policies, by recommending to steam rather than to boil, and to boil for a short time when boiling (Anonymous, 2005). However, it is not known which preparation method is most accepted by children.

Preparation is an easy way by which parents can influence sensory properties, and may be able to optimise acceptance of vegetables for their children. The current study aimed to investigate to what degree cooking time and cooking method affects children's acceptance of two common *Brassica* vegetables, broccoli and cauliflower. The study compared high and low vegetable consumers. From a public health perspective, identifying ways to increase vegetable acceptance of low vegetable consumers is most relevant.

2. Materials and methods

An experimental taste test was conducted in which 5–6 year old children tasted and evaluated two *Brassica* vegetables each prepared in six different ways by systematically varying cooking method and cooking time.

2.1. Participants

Eighty-two children (41 boys, 41 girls) and one of their parents participated in the study. Five and six year old were chosen as a study group, as they are part of the age category of 3–6 year old where food neophobia reaches its peak (Köster & Mojet, 2006), and they have the cognitive abilities and attention span to rate samples for acceptance (Guinard, 2000; Popper & Kroll, 2005). Children were recruited by advertising in local media, schools, child-care centres and nearby worksites, and partially via an external recruitment agency. The group was balanced for vegetable consumption, with the criterion chosen a priori as ≤ 1 serve/day for low and ≥ 2 serves/day for high vegetable consumers, using a validated measure for vegetable intake (Ball, Crawford, & Mishra, 2006). Australian children consume an average of 1.3 serves of vegetable per day (Bowen, Klose, Syrette, & Noakes, 2009), whereas 2 serves are recommended (National Health, 2003). Children were excluded if they or one of their parents had any food intolerance or food allergy. Children who had never consumed the target vegetable(s) were excluded only if they had never consumed and/or clearly disliked at least half of the vegetables from a list of 24 common vegetables. In practice the latter criterion did not lead to exclusion of any child. Written consent was obtained from the parent for their child and themselves prior to the start of the test. Children/parent pairs received a \$50 retail gift voucher for participation. The research was approved by the CSIRO Human Research Ethics Committee.

2.2. Samples

The target vegetables in this study were two common types, broccoli and cauliflower, from the *Brassica* family. Six variations of each vegetable were created using two cooking methods, boiling and steaming, with three times of cooking for each, short, medium, and long. The cooking times were developed on the basis of iterative pre-tasting of samples by four staff, two of which were experienced in sensory descriptive analysis. The aim was to select cooking times that were sufficiently different in sensory properties to potentially lead to differences in acceptance, within a range used in domestic cooking (Poelman, Delahunty, Gilbert, & Forde, 2009). For each cooking time point, boiled and steamed vegetables were matched for *firmness*, so that any flavour differences between samples of different cooking methods could be attributed to this cooking method, without being confounded by firmness differences. Boiling times were 2–6–10 min for broccoli and 2–7–12 min for cauliflower; steaming times were matched to provide the same sensory *firmness* perception in-mouth, i.e. 3–7.5–12 min for broccoli and 3–8.5–14 min for cauliflower (Table 1).

Steaming was conducted using steamer baskets in pots on a gas stove. Samples were cooked fresh for each session in separate pots. Cooking start times of all six samples within a vegetable type were staggered with the use of detailed, timed, cooking protocols in such a way that all samples finished at the same time, and were served immediately. Two florets (approximately 4 cm in diameter, 1 cm stalk, weight 14–15 g) for each sample were served in polystyrene foam cups with a lid, and consumed hot at approximately 60 °C.

2.3. Procedure

Research took place in the sensory research facilities of CSIRO, Sydney, Australia. Children, and one of their parents, took part in a single 45 min session, with a maximum of three children per session. Oral group instructions were provided first, after which child/parent pairs were seated in separate, adjoining rooms. Each child had one-on-one assistance from a research staff member. Parents were seated so that they were not in viewing distance of the child. They completed a questionnaire and were instructed not to interact with their child during the test.

Within one session all children started with the same vegetable type for logistical reasons. Across sessions the design was balanced for serving order of vegetable type, by alternating sessions in which all children started with broccoli with sessions in which all children started with cauliflower. The child was first served with a tray containing the six samples of one vegetable type. The sample order of the six samples on the tray was randomised. The child tasted and evaluated the vegetable samples one by one as provided to them by the research staff member. They were instructed to taste the sample by biting a part of the floret and the stem. Then they placed the sample below the appropriate image of a five point hedonic facial scale (Guinard, 2000), which was

Table 1

Vegetable cooking times by cooking method for the two vegetable types after selection of boiling times, steaming times were adjusted so that samples matched in terms of sensory *firmness*. Statistical analysis (ANOVA) confirmed this was successful ($p > 0.05$ for each boiled/steamed pair of the same cooking time).

Vegetable	Cooking method	Cooking range		
		Short (min)	Medium (min)	Long (min)
Broccoli	Boiling	2	6	10
	Steaming	3	7.5	12
Cauliflower	Boiling	2	7	12
	Steaming	3	8.5	14

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