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# Vegetable acceptance by infants: Effects of formula flavors

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## KEYWORDS

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Weaning;  
Flavor;  
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Formula;  
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**Abstract** Individual differences in acceptance patterns are evident as early as the child's first experiences with a particular food. To test hypothesis that the flavor of formula fed to infants modifies their acceptance of some foods, we conducted a within- and between-subjects design study in which two groups of 6- to 11-month-old infants were tested on two separate days. One group was currently feeding a milk-based formula whereas the other was feeding a protein hydrolysate formula, a particularly unpleasant tasting formula to adults that contains similar flavor notes (e.g., sulfur volatiles) with Brassica vegetables such as broccoli. In counterbalanced order, acceptance of pureed broccoli/cauliflower was determined during one test session and pureed carrots on the other. Although there were no group differences in the amount of carrots consumed, hydrolysate infants consumed significantly less broccoli/cauliflower relative to carrots when compared to those who were currently fed milk based formulas ( $F(1, 72 \text{ df})=4.43$ ;  $p=0.04$ ). The mothers of hydrolysate infants were significantly more likely to report that their infants did not enjoy feeding the broccoli/cauliflower (54.2%) when compared to mothers of infants being fed milk-based formulas (28.0%; Chi-Square (1  $df$ )=4.79;  $p=0.03$ ). Such findings are consistent with prior research that demonstrated a sensory specific satiety following repeated exposure to a particular flavor in milk. We hypothesize that when infants are experiencing a flavor in milk or formula, in the short term, the preference that develops is specific to the context it is experienced in (e.g., milk). Over the longer term, the preference may generalize to other contexts such as solid foods. Hydrolysate infants were also significantly more likely to be judged by their mothers as being more active ( $F(1, 69 \text{ df})=3.95$ ;  $p=0.05$ ) and hesitant ( $F(1, 69 \text{ df})=6.55$ ;  $p=0.01$ ) when compared to those infants who were feeding milk-based formulas, a finding that further supports the hypothesis that mother–child dynamics surrounding early feeding impacts upon mothers' perception of their children's temperament. © 2006 Elsevier Ireland Ltd. All rights reserved.

## 1. Introduction

Up to one third of American children under the age of two consume no fruits or vegetables on a given day [1]. Because fruit and vegetable experiences during infancy track into childhood and adolescence [2,3], developing strategies to

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enhance acceptance of these foods early in life are important for long-term health [4]. However, such strategies need to take into account the individual differences in acceptance patterns that are evident as early as the child's first experiences with a particular food [5].

Although the source of such individual differences remains a mystery, prior research has shown that the very earliest flavor experiences, that which occurs in utero and during milk feedings, can influence food acceptance at weaning. The degree of acceptance depends on the length of time that has elapsed since exposure to the flavor as well as the sensory context in which the flavor is experienced. For example, breast-fed infants whose mothers consumed a diet rich in carrots exhibited a decrease in their acceptance of carrot-flavored cereal when tested shortly after the exposure period [6,7]. This may be a form of sensory-specific satiety, such that the infants become less responsive to a flavor that they have been extensively exposed to in the very recent past [8].

Over the longer term, exposure to carrot flavor served to heighten its acceptance. That is, infants who were exposed to the flavor of carrots prenatally or during the first months of life in mothers' milk and were tested several months later, were more accepting of carrot-flavored cereal than were infants without such experience [9]. Presumably, learning (e.g., elimination of neophobia, conditioning, "mere exposure") has occurred.

The present study expanded upon these findings to experimentally investigate this issue in infants who are formula feeding. Here we take advantage of the marked differences of commercial infant formulas. In particular, the sensory quality differences between the hydrolysate and milk-based formulas are striking and profound. To most adults, who are tasting these products for the first time, milk-based formulas are described as having low levels of sweetness and tasting > 'sour and cereal-like', whereas hydrolyzed protein-based formulas are of a most unpleasant character with a bitter and sour taste profile, unpleasant odor volatiles and a horrible after taste [10–12]. The extreme unpalatability of hydrolysate formulas, which supply infants with protein nutrients in a > 'predigested' form, is likely due to both its processing and composition since major amino acids and small peptides taste sour and bitter and is characterized by unpleasant volatile components [13–15]. Because hydrolysate formulas [16] contains similar flavor notes (e.g., sulfur volatiles) with broccoli [17], the present study tested the hypothesis that infants currently feeding hydrolysates would reject broccoli in the short term when compared to a group of infants being fed milk-based formulas.

## 2. Methods

### 2.1. Subjects

Women, who were formula feeding an infant, were recruited from ads in local newspapers. The racial background of the mothers was 44.6% Black, African descent, 45.9% White, European descent, 4.1% Hispanic, 2.7% Asian and 2.7% Admixed/Other Ethnic Groups. All infants were born full-term and were healthy at the time of testing, as reported by their mothers.

Two groups of infants, whose ages ranged from six to eleven months, were formed on the basis of the type of formula they were feeding. Group 1 infants ( $N=50$ ) were feeding a milk-based formula and had never experienced hydrolysate formula (Mean age =  $8.5 \pm 0.2$  months), whereas Group 2 infants ( $N=24$ ) were feeding the protein hydrolysate formula, Nutramigen™ (Mean age =  $8.9 \pm 0.3$ ). As expected, those who were feeding Nutramigen often fed a milk- or soy-based formula during the first months ( $1.8 \pm 0.4$  months) of life and then, usually following their paediatrician's recommendation, were switched to hydrolysate for such reasons as the baby was experiencing colic, allergies, or constipation. None of the infants fed milk-based formulas had ever experienced hydrolysate formulas. Six additional infants were tested but were excluded because either the mother did not comply with study procedures ( $N=1$ ) or because the infant in the milk formula group (Group 1) had prior experience with hydrolysate formulas ( $N=5$ ). The study procedures were approved by the Office of Regulatory Affairs at the University of Pennsylvania, and informed consent was obtained from each woman before the start of the study.

### 2.2. Procedures

A within- and between-subjects design study that controls for time of day since infants were last fed was conducted. To accustom infants to the testing procedures [6], mothers were sent a bib and spoon to use when feeding their infants during the 3 days before the first testing session and throughout the 2-day experimental period. They were asked to refrain from introducing additional foods or beverages to their infants during this time period.

### 2.3. Foods

All foods used in this experiment were commercially available infant foods from Gerber Products Company (Fremont, MI, USA). The foods were Stage 2 pureed carrots (35 calories/jar) and pureed broccoli/cauliflower (60 calories/jar). The maximum amount of food that could be extracted from one jar was approximately 113 g.

### 2.4. Monell test sessions

Each mother–infant pair was tested on two days separated by, on average, two days ( $\pm 0.3$ ). The infants' weights and lengths prior to feeding were recorded and their Body Mass Indexes (BMI) were determined. To minimize possible effects due to different levels of satiation, the two test sessions took place at the same time of day and infants were last formula fed, on average, 3.9 ( $\pm 0.3$ ) h and last fed solid foods, on average, 9.1 ( $\pm 1.0$ ) h prior to the testing sessions. There was no significant difference between the groups in the length of time since the infants were last fed ( $F(1, 71 \text{ df}) = 0.04$ ;  $p = 0.95$ ).

Following a brief period of acclimation, mothers were videotaped as they fed their infants, in counterbalanced order, pureed carrots during one test session and pureed broccoli/cauliflower during the other. Carrots were chosen because it is generally well accepted by infants [5]. The

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