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INFANT ACCEPTANCE AND TRAINED PANEL QUALITY EVALUATION OF PURÉED VEGETABLES

by

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INTRODUCTION

Little is known about infant taste sensitivity and how it may affect food preferences. In fact, very little is known about the types of food infants like or dislike. Previous research has shown that infants can taste and exhibit innate facial responses to various stimuli. Because these responses appear to indicate good and bad-tasting substances, it was felt that this technique could be used to measure infant food preferences.

Vegetables were selected as the food group of interest because they have been consistently found to be the least-favoured food group by children and adults. Because future food habits may be based on those formed in the early years of life, it was felt that this area should be investigated.

REVIEW OF LITERATURE

I INFANT TASTE SENSITIVITY

A. Taste Bud Development

1. Human Fetus

Histological studies indicate that taste receptors in humans are developed before birth. Researchers, however, disagree on the time taste buds make their first appearance in the fetus. Arey (1946) described presumptive taste buds in the human fetus at the end of the second or beginning of the third fetal month. Bradley and Stern (1967) analyzed seventy specimens of human foetal tongues. Presumptive taste buds were found at nine weeks in utero and the adult form of taste buds at thirteen - fifteen weeks. Steiner (1974) observed the adult form of taste buds in the fifth gestational month. In 1889, Tuckerman (Farbman, 1972) did not discover taste buds in fetuses less than seven months of age.

2. Animal Fetus

Animal studies also reveal that taste bud development begins in utero. Early research in this area has been reviewed by Farbman (1972). Precursors of taste buds were found in rabbit fetuses by Herman in 1885, and were believed to be fully developed at seven days after birth. However, in the late 1800's, von Wyss and Lustig both stated they saw fully developed taste buds in the newborn rabbit.

In fetal sheep, presumptive taste buds were found at seven weeks gestation, and by fourteen weeks, these were morphologically similar to adults (Bradley et al, 1972). In the rat, development begins before birth but is completed several days after (Torrey, 1940; Farbman, 1965). Taste buds have been reported on the tongues of newly hatched chicks (Lindenmaier et al, 1959).

Despite the variations in the time of appearance of taste buds, it appears that in both animals and humans, taste bud development begins in embryonic life. In human fetuses, this development is complete at birth.

B. Taste Sensitivity

1. Human Fetus

Some evidence exists which suggests that human taste buds may be functional before birth. In 1937, de Snoo injected saccharin into the amniotic fluid of fetuses. This resulted in an increased amount of amniotic fluid swallowed. Fetal reaction to an unpleasant tasting substance resulted in a decreased amount of amniotic fluid swallowed (Liley, 1972). Increases and decreases of swallowing by foetal sheep was not evident when glucose and the bitter denatonium benzoate were injected into the amniotic fluid (Minstretta, 1975).

2. Newborn Infants

Numerous investigations have demonstrated that the taste receptors of the newborn infant are functional. Much of the early work in this area was conducted by European researchers in the late 1800's and early part of the 1900's. A review of the literature on infant taste sensitivity has been conducted by Peiper (1963). The interpretation and comparison of early and more recent studies has been difficult. In some cases, the data were not statistically analyzed, a variety of stimuli and varying concentrations were used, stimulus concentrations were not always reported, or the method of measuring infant response varied.

i) Criteria for Determining Taste Sensitivity

The majority of researchers used the degree of sucking movements, facial expressions, or a combination of both, as the criterion of taste sensitivity (Kussmaul, 1895; Preyer, 1895; Eckstein, 1927; Kulakowskaja, 1930; Pratt et al, 1930; Jensen, 1932; Stirniman, 1936; Martin Du Pan, 1955; Aiyar et al, 1969; Steiner, 1974). In general, infant response to unpleasant stimuli has been characterized by facial grimaces, tight shutting of the eyes, opening or grimacing of the mouth and/or protrusion of the lips and tongue. Sweet stimuli elicit eager sucking movements and licking. Some investigators agree that infants can differentiate tastes and exhibit facial expressions characteristic of a particular taste (Kussmaul, 1895; Preyer, 1895; Steiner, 1974). In 1938, Stirniman reported that a facial expression characteristic of a particular taste sensation was non-existent.

Peiper (1963) stated he was only able to distinguish expressions caused by "good" or "bad" tasting stimuli. Aiyar et al (1969) was unable to determine whether newborns are capable of differentiating unpleasant tastes.

More recent investigators have based their studies on infant taste sensitivity on the volumes of solutions consumed within a set time period (Dubignon et al, 1969; Desor, 1973; Maller et al, 1974; Desor et al, 1975). No time limit for volume of solution ingested was used in a study by Nisbett et al (1970). Nowlis et al (1976) used a specially designed nipple to monitor pressures exerted by the infant's mouth during sucking. An eyelid conditioned response to taste stimuli was used by Osepian (1958).

ii) Preference for Sweet-Tasting Solutions

Regardless of the criteria used to determine sensitivity, the researchers are in agreement that newborn infants exhibit a preference for sweet-tasting solutions. Desor (1973) reported that newborn infants prefer solutions of sucrose, fructose, glucose and lactose over unsweetened water. As the concentration of sugar increased, the volume ingested increased. In addition, the sweeter sugars, sucrose and fructose, were preferred. Similar findings have been reported by Dubignon et al (1969), Nisbett et al (1970) and Nowlis et al (1976). Aiyar et al (1969) studied the facial reactions of ten thousand newborns and found that only solutions of sucrose induced licking and sucking, indicating the pleasant nature of the stimuli. Steiner (1974) reported that a twenty-five percent

sucrose solution elicited eager sucking and a look of satisfaction resembling a smile.

iii) Sensitivity to Salty Stimuli

Infant sensitivity to salty stimuli has been more contradictory. Less attention has been focused on this area in recent studies, possibly due to the danger of hypertonicity Desor et al (1975) observed that neonates appeared indifferent to varying concentrations of sodium chloride (maximum 0.2M) when mixed with water or with a dilute sugar and water solution. Fomon et al (1971) demonstrated that infants, four to seven months of age, showed no preference between salted and unsalted strained baby foods. Jensen (1932) found infants reacted positively toward salt solutions, while Aiyar et al (1969) found infants expressed negative facial expressions to mild and strong salt solutions. Osepian (1958) observed that sucking movements for salt solutions were irregular and feeble compared to vigorous sucking for sugar solutions.

iv) Sensitivity to Sour Stimuli

Evidence exists to support the ability of newborns to taste sour stimuli. Early researchers used vinegar, lemon juice or citric acid solutions as stimuli. Newborn infants were reported to exhibit expressions of dislike (Kussmaul, 1859; Preyer, 1895; Pratt et al, 1930; Kulakowskaja, 1930). Irregular and feeble sucking of citric acid solutions by infants were observed by Osepian (1958). Negative facial expressions were reported by Aiyar et al (1969). Steiner (1974) presented a 2.5% citric acid solution to newborns which

elicited a facial expression described as a pursing and marked protrusion of the lips and rolling of the tongue. These reactions were frequently accompanied by a wrinkling of the nose or blinking. In 1974, Maller et al, observed newborn infants were indifferent to citric acid and water solutions (0.001M to 0.012M). Desor et al (1974) used higher concentrations of citric acid (.012M) and again indifference was observed. These same researchers added varying concentrations of citric acid to a dilute sucrose (.07M) solution and observed a decreased intake of it compared to that for the sugar solution. This aversion to sour was not seen when water was used as the basis for comparison. This difference was attributed to the basement effect of water, that infants may find water aversive and thus consume as little of it as possible.

v) Sensitivity to Bitter Stimuli

Research on infant sensitivity to bitter compounds is controversial. The majority of early investigators indicate that infants find bitter substances aversive (Kussmaul, 1859; Preyer, 1895; Eckstein, 1927; Stirniman, 1930). A variety of substances have been used as bitter stimuli - urea, chloroquin, quinine sulphate and quinine. Kulakowskaja (1930) observed most infants negatively responded to a 0.05% quinine solution. However, Pratt (1930) found infants were ambiguous in their responses to a 0.25% quinine solution. Aiyar et al (1969) presented mild and strong solutions of chloroquin to ten thousand infants. Over ninety-five percent of the subjects responded with definite negative reactions to the mild solution.

The strong solution induced crying and dislike facies in the entire sample, and vomiting and retching in forty-six percent and eighty-four percent of the sample respectively. The concentrations used were not reported, but the violent reactions to the latter suggest an extremely high concentration of chloroquin. Presentation of a 0.25% quinine sulphate solution to one hundred and seventy-five neonates resulted in definite reactions of dislike (Steiner, 1974). Facial expressions suggested anger, aversion and dislike. In contrast with these findings, Maller et al (1974) and Desor et al (1975) reported that infants remained indifferent to varying concentrations of urea (0.03 to 0.48M) in water or in a dilute sucrose and water medium.

Thus it appears that newborn infants have an innate preference for sweetness and find sourness aversive. The ability of infants to taste very strong bitter solutions has been seen and their reaction was one of dislike. However, it is unclear from these findings that infants dislike or can even taste weaker bitter solutions.

3. Taste Sensitivity of Older Infants

The majority of the studies focused on the taste sensitivity of the newborn. Osepian (1958) studied taste sensitivity for sucrose, sodium chloride and ascorbic acid in infants through the first year of life. He reported increasing sensitivity with growth and development which reached a minimum at one year of life.

C. Number of Distribution of Taste Buds

1. Infants

In the infant, the area of taste sensitivity is more extensive than in the adult (Peiper, 1963). According to Von Skramlik (1926) the infant possesses areas of taste sensitivity which the adult does not. These are the whole dorsum lingae, the tip of the tongue, the hard palate and possibly the mucosa of the lips and cheeks. Arey et al (1935) agrees that human infants have a wider distribution of taste buds in the oropharnyx and a greater number of taste buds than do adults.

2. Children and Adults

In the adult, the number of taste buds begin to decline with age (Arey et al, 1935; Laird et al, 1939; Richter et al, 1940; Cooper et al, 1959; Glanville et al, 1964). In early childhood, taste buds are present not only on the tongue, but on the inside of the cheeks and throat. During adolescence, those on the tongue remain while others disappear. Little change takes place until much later in life when there is a decline in the number of taste buds. In young and middle-aged persons, two hundred and six taste buds per papillae were found (Arey et al, 1935). In the forty-four to eighty-five year age group, this number decreased to eighty-eight.

D. Relationship Between Number of Taste Buds and Taste Sensitivity

Some authorities are of the opinion that a child has a keener sense of taste than adults and have related this to the greater number of taste buds in the child or greater sensitivity of the child's taste buds (Laird et al, 1939; Lowenberg, 1948, 1953; Hurlock, 1956; Glaser, 1957). Although no investigators have expressed this same theory for infants, it would seem that they too should be more sensitive than adults. However, a review of the literature indicates the relationship between number of taste buds and taste sensitivity is controversial.

1. Infant and Adult Response to Stimuli

Investigation has shown that adults respond to more dilute chemical solutions than infants do (Kulakowskaja, 1930). Infants responded to a 0.05% quinine solution while adults could taste the 0.004% solution. Kulakowskaja (1930) also reported that adults responded to lower citric acid concentrations than did infants. This is interesting in that Pratt et al (1930) reported infants exhibit a strong reaction to a 2.14% citric acid solution which the adult experimenters found rather weak. The bitter, sour and salty solutions used by Maller et al (1974) and Desor et al (1975) were said to be neutral to unpleasant to adults. Infants remained indifferent to all these substances when mixed with water only.

2. Effect of Age on Taste Sensitivity

Evidence to support the view that taste sensitivity decreases with a decrease in taste buds has been reported. Richter et al (1940) found subjects between fifty-two and eighty-five years had sucrose taste thresholds almost three times as great as subjects fifteen to nineteen years. They suggest the decrease in taste buds as a possible cause. Cooper et al (1959) tested the difference and taste thresholds for the four modalities of taste for one hundred subjects of varying ages. Results for both tests were similar, showing a noticeable decline in sensitivity after the late fifties. Glanville et al (1964) studied the effects of aging on taste sensitivity to 6-n-propylthiouracil, quinine and hydrochloric acid. Subjects ranged in age from three to fifty-five. Increased sensitivity to all three substances was exhibited up to sixteen to twenty years, followed by an exponential decline.

Feeney et al (1966) found no evidence to support the view that pre-school children were more taste sensitive than their parents. Results revealed that parents always had the lower threshold. Investigation by Byrd et al (1959) presented little evidence of a decrease in taste sensitivity with age. No statistically significant differences were found for the four taste qualities between three age groups containing twenty subjects: eighteen to twenty-five, sixty to seventy and eighty to ninety years. However, the frequencies were consistently lower for the oldest age group.

3. Taste Sensitivity of Animals

The significance of the number of taste buds and taste sensitivity is questionable in animal studies as well. Chickens possess approximately twenty-four taste buds and yet will totally avoid chemical dilutions almost imperceptible to man (Lindenmaier et al, 1959; Kare et al, 1975). Chickens can perceive some solutions at concentrations imperceptible to the cow which has a thousand times as many taste buds. Observations on rats (Pfaffman, 1952) indicates it is unlikely that any changes in taste sensitivity with age is directly dependent upon the number of taste buds.

III INFANT FEEDING

A. Incidence of Breast-Feeding

The incidence of breast-feeding has changed over the years. Approximately sixty-five percent of infants were breast-fed in the 1940's (Bain, 1948). By 1958, only twenty-five percent of seven-day old infants were breast-fed (Rivera, 1971). In 1962, Rueda-Williamson reported that only three infants out of sixty-seven were breast-fed longer than three months. In 1969, Harris et al reported forty-one percent of three hundred and eighty-three infants were breast-fed for various period from birth to one month of age. Maslansky (1974) analyzed the diets of four hundred and fifty-one infants in New York City and found that only seventeen percent were breast-fed at some time. Fomon (1974) estimated that approximately twenty percent of infants less than one month of age will be breast-fed today.

B. Introduction to Solids

The age at which infants are introduced to solids has varied greatly over the years. Before 1920, solids were seldom offered before one year of age (Committee on Nutrition, 1958). By the 1930's, Marriott (1935) suggested six months of age as the proper time to introduce solids. In 1937, the Council on Foods of the American Medical Association favored the feeding of strained fruits and vegetables at about four to six months. A survey of two thousand pediatricians in 1954, showed eighty-eight percent in favour of introducing solids before three months of age and sixty-six percent before eight weeks of age (Butler et al, 1954). An extremely early introduction to solids was advocated by Sackett in 1956. Feeding of cereals was begun by the second or third day of life, vegetables at ten days, meats at fourteen days and fruits at seventeen days. In 1958, the American Academy of Pediatrics reviewed the research available on feeding solids and concluded that "no nutritional superiority or psychologic benefit results from introduction of solid foods into the infant diet prior to two and one half to three months of age." [1] They suggested that the age at introduction to solids may have been five to six months in 1948 and six weeks or less in 1958. Anderson et al (1975) recommend that solids be introduced at about six months of age, as an adequate

1. Committee on Nutrition: On the feeding of solid foods to infants. Pediatrics 21:691-692, 1958.

intake of all essential nutrients can be met without solids. In 1976, the Manitoba Department of Health and Welfare, in conjunction with the Section of Pediatrics, Manitoba Medical Association, recommend introducing solids no earlier than three to four months.

Beal (1957) studied a group of infants in Denver from 1946 to 1955 and found that strained foods were offered at increasingly early ages. More recent studies have reported introduction to solids as early as four to six weeks (Epps et al, 1963; Harris et al, 1969; Maslansky et al, 1974). As these studies have been centered on select communities, the results are not representative of the population on infants in general. The data is inadequate to determine current trends in introducing solids over the last ten to fifteen years (Fomon, 1975). Several researchers have reported that the majority of mothers introduce solids at an age earlier than that recommended by physicians (Epps et al, 1963; Harris et al, 1969).

The order in which solids are introduced is usually cereal, fruit, vegetables and meat introduced last (Harris et al, 1969; Maslansky et al, 1974). Some pediatricians believe that infants should be introduced to vegetables before fruit, as the sweet taste of fruit may interfere with vegetable acceptance. However, there has been no evidence to support this theory. The Manitoba Department of Health and Social Development (1976) recommends cereals be introduced at three months, vegetables at four, fruit at four and one-half and meat at six months.

C. Feeding Practices and Food Preferences

The food preferences of infants have so far met with little study. Several studies on infant feeding practices have provided some general information on the types of food preferred by infants.

Maslansky et al (1974) analyzed one-day dietary histories of four hundred and fifty-one infants. Fruit and fruit juices were found to be favoured. Approximately forty percent of infants less than three months old had received fruit juices. Orange juice and apple juice were most popular. Applesauce was the most widely used fruit, followed by bananas, pears and peaches in second place. Vegetables were introduced to thirty percent of the infants at less than three months of age. By six months, forty-eight percent were eating vegetables. Carrots were preferred by the younger group, followed by peas and beans. At four to six months, carrots were slightly less favoured. Thirty-nine percent of the infants received cereal by three months, but the authors did not report their acceptance.

Results of a questionnaire given to three hundred and eighty-three mothers in the Mayo Clinic Well Baby Clinic in 1969 have been reported (Harris et al, 1969). Approximately eighty percent of the infants had received cereal by one month. Rice was the cereal most frequently used initially. Only thirteen infants were reported to dislike or refuse cereal. At one month of age, more than half the infants received fruits and by two months, eighty-three percent were

consuming fruit. The fruit most popular was applesauce, bananas and pears a weak third. The order of vegetables preferred was carrots, sweet potatoes and squash. Mothers reported more problems with the acceptance of meat than with any other food group. Thirty percent reported that all meats were spat out or refused. Among those infants who accepted meat, beef and chicken were the favourite. Mothers reported that major feeding problems involved the refusal of foods because of either taste or texture. At the time of the survey, infants were aged ten to twenty-five months. The results of this study are dependent upon the mother's ability to recall feeding practices conducted many months before.

From 1946 to 1957, Beal (1957) followed the nutrition of fifty-seven infants at regular intervals since birth. It was reported that the average child did not willingly accept any solid food before the age of two and one-half months. Thirty-seven children were offered cereal by two months of age. Of these, approximately thirty percent accepted it well when first offered. The author reported marked preferences for certain foods. Fruits in general were especially liked by seventy percent of the infants. Banana and applesauce were the favourites. Vegetables as a group were less popular. One-third of the group liked yellow vegetables, while beets were especially disliked by forty percent and spinach by sixty percent. Liver was disliked more than any other meat.

In 1966, Guthrie observed the acceptance of solid foods by fifty-six infants. Fruits were better accepted than cereals while

vegetables were found to be generally unacceptable. Specific foods were not reported as being especially liked or disliked. Although the author did not question the mother's attitude toward her feeding practice, remarks received suggested a feeling of pride in the development of her infant's eating habits.

Only one study has been found that focused directly on vegetable preference (Martin Du Pan, 1955). Fifty-eight infants, ages three to eight months, were fed a variety of commercially-strained vegetables, namely, peas, tomatoes, carrots, beans and mixed vegetables. Preferences were determined on the basis of the infant's gustofacial response and rated on a five point category scale. Carrots were the only vegetable found to be significantly preferred over all other vegetables.

D. Methods Used to Determine Infant Acceptance of Solids

Measurement of plate waste has been used to determine infant acceptance of solids (Fomon, 1970; Gonzales, 1972). Other investigators have used interviews, one-day dietary records, or questionnaires to determine acceptance or rejection of certain foods (Van Leeuwen, 1969; Harris et al, 1969; Maslansky, 1974). The criterion of acceptance used by Beal (1957) was the willingness of the infant to swallow the food without protest, two weeks after it was initially offered. Martin Du Pan (1955) used facial expressions as the measurement tool for infant vegetable preferences.

E. Use of Commercially-Prepared Infant Foods

Only two types of baby food are known to this writer: commercially-prepared products and those prepared at home. Excluding the investigations of Martin Du Pan (1955), none of the studies cited has indicated which type of product was used. However, it is believed that almost all solid food fed to infants less than six months of age, is commercial baby food (White Paper on Infant Feeding Practices, 1974). There are no studies reported in the literature on the preferences of infants for home-prepared foods.

III VEGETABLE PREFERENCE BY CHILDREN AND ADULTS

Many researchers believe that food habits and attitudes towards food are established during the early years of life - infancy and pre-school years (Wagner, 1954; Litman et al, 1964; Kerrey, 1968; Beyer, 1974).

Forty years ago, researchers have observed that vegetables were among the food groups least liked, particularly by young children (Prentiss et al, 1930; Vance, 1933; McCarthy, 1935). Today, the same situation exists, with both adults and children possessing a less favourable attitude towards vegetables (Hall et al, 1939; Lamb et al, 1954; Potgieter, 1955; Mirone, 1956; Breckenridge, 1959; Pilgrim et al, 1960; Pilgrim, 1961; Dierks et al, 1965; Eppright,

1969; Harrill et al, 1972; Beyer et al, 1974).

The food habits of one hundred and twenty-one pre-school children were investigated by Dierks and Morse (1965). Their most striking observation was the frequency with which vegetables in general, and specific vegetables were disliked or not eaten at all. Beets and corn were among the few vegetables liked. Twenty-two specific vegetables were refused by one or more of the children. Fourteen children refused all vegetables. By contrast, meat, fruit and sweets were among the more popular foods.

In 1959, Breckenridge studied food attitudes of fifty-one children, ages five to eleven years. Cooked vegetables of all kinds comprised the largest number of food dislikes. A recent study by Harris et al (1972) reported that the majority of pre-school children served a noon-day meal, did not like green vegetables. In addition, other vegetables were eaten sparingly.

A recent study by Beyer and Morris (1974) found that eating habits remained fairly constant from pre-school to elementary school years. The food habits of forty-four children were followed, and cooked vegetables were discovered to be the least liked during both periods. Eighty-one percent of the pre-school children listed a vegetable as his most disliked food. This trend continued to the elementary school years.

Several studies have shown that vegetables are not well liked by adults either (Bryan et al, 1958; Pilgrim et al, 1960). A study of food preferences in the United States Armed Forces revealed that

very few vegetables appeared to be well liked. Pilgrim (1961) suggested that the Army food preferences may be similar to that of the American people.

In 1958, Bryan and Lowenberg studied the food preferences of sixty-one pre-school children and their fathers. Both groups shared a common dislike for vegetables. Taste, odor and texture were the reasons most often cited for food dislikes (Hall et al, 1939; Bryan et al, 1958). Eighty-nine percent of the mothers avoided or serve infrequently, those foods disliked by the father.

RESEARCH DESIGN

I OBJECTIVES

The following study was designed to gain insight into the development of taste sensitivity in the infant and infant vegetable preferences. The objectives of this study were:

1. To determine infant acceptance of vegetables in general.
2. To determine if infants exhibit a preference for fresh-frozen or canned puréed vegetables.
3. To determine if the introduction of fruit before vegetables influences vegetable acceptance.
4. To define the sensory characteristics of the vegetables used by means of a trained sensory panel.

II HYPOTHESES

The following hypotheses were formulated to carry out these objectives:

1. Infants will exhibit likes and dislikes for vegetables.
2. Acceptance of vegetables by infants in general, will be low.
3. Infants will exhibit greater preference for frozen vegetables than for canned vegetables.
4. Older infants will exhibit more vegetable preferences than younger infants.
5. Infants fed fruits before vegetables will have a lower preference for vegetables.

6. There will be some sensory link between those vegetables liked and those disliked.

III PRELIMINARY WORK

A. Home Interviews

To acquire further information on current infant feeding practices, twenty-five mothers in the City of Winnipeg with infants less than one year of age were interviewed. Twelve of these mothers were referrals from the Fort Garry Public Health Office, six were mothers whose children attended the Infant Laboratory at the Family Studies Department, Faculty of Home Economics, University of Manitoba, and the remainder were referrals from women previously interviewed. The interview focused primarily on age of introduction of solids, use of commercial and home-prepared foods and infant food likes and dislikes. All mothers indicated that their infants had definite food preferences and that physical expressions were good indicators of these food preferences. The feasibility of conducting the following study was discussed and all mothers expressed enthusiasm and interest in a project of this nature.

B. Taste Panel

Preliminary taste panels were conducted on all puréed vegetables carried by the three manufacturers of baby foods in North America - Beech-nut Corporation, H. J. Heinz Company and Gerber Products.

Results of the panels illustrated that these foods possess a wide variety of taste sensations as well as a variety of textural characteristics. Puréed vegetables were prepared from previously frozen vegetables and were analyzed by a sensory panel. The frozen samples were stored at -25°C. for two months and showed no deterioration in quality.

IV INFANT INVESTIGATION

A. Selection of Subjects

1. Prenatal Clinic

Subjects for the study were contacted through the St. Boniface Hospital Prenatal Clinic. Any research related to infants associated with the St. Boniface Hospital must first be approved, therefore, a draft of the proposed study was submitted to the Head of the Pediatrics Department. The proposal was approved and permission to contact members of the Prenatal Clinic was received from the Head of the Family Practice Department at the St. Boniface Hospital.

A list of names of mothers who attended the Clinic from February to June, 1976, was provided by the dietitian in charge of the nutrition component of the clinic. In July, a letter (Appendix A) explaining the nature of the study was sent to all parents whose infants were born in April, May and June, or whose due dates were in July or August. The letters were followed by a telephone interview a few days later and further details of the study were explained at that time.

2. Criteria for Participation

Only those infants who had no previous exposure to vegetables were eligible to participate. It was essential that each household have a freezer for storage of the frozen samples. Mothers were informed that they were free to introduce vegetables at any time they wished, but must adhere to a schedule drawn up by the researcher. If fruit had not been introduced, mothers were asked to consider introducing vegetables first. The majority of mothers had introduced fruit already or intended to introduce fruit first.

3. Ineligible Contacts

Fifty of the ninety-seven contacts were very willing to participate. Thirty-six contacts were ineligible as vegetables were already present in the infant's diet. Two mothers refused to participate as they did not want to use commercially-prepared products. The remaining ineligible contacts consisted of five mothers who intended to breast-feed for an undetermined length of time, one who did not have a freezer and three who were moving out of the city. Mothers agreeing to participate were contacted a few weeks later to arrange a convenient date for delivery of supplies and instructions.

B. Preparation of Samples

1. Selection of Vegetables

Four varieties of vegetables were used in this study: peas, carrots, green beans and corn. These were selected because they are

among those vegetables frequently served to infants.

2. Canned Puréed Vegetables

Four and one-half ounce jars of strained vegetables prepared by H. J. Heinz Company were selected as no other brand is available in Winnipeg. To guard against harvesting and processing variations, each vegetable was purchased in more than sufficient quantity from the same lot number. To prevent biasing the subjects' mothers, labels were removed and the lids painted grey. Each jar was labelled accordingly and stored at room temperature.

3. Frozen Puréed Vegetables

The frozen samples were prepared in the Foods and Nutrition Laboratory, Faculty of Home Economics, University of Manitoba. All equipment was sterilized before and after each preparation. Sterilized plastic medical gloves were worn throughout the entire preparation period.

Signet brand frozen green peas, sliced carrots, niblet corn and French-style green beans were purchased from the same lot number to guard against harvesting and processing variations. The vegetables were boiled in water only, until tender and puréed in a Waring commercial blender. The procedure used for each vegetable is outlined in Appendix B. The puréed green beans and corn were passed through a sieve to remove the fibrous particles. It was not necessary to strain the peas and carrots.

One and one-half ounce wax-coated portion cups were filled with the puréed vegetable, covered and frozen overnight at -25°C. Each of the frozen samples was transferred to individual sterilized bags, and labelled accordingly. Zip-loc freezer bags were filled with three samples of each vegetable and stored at 25°C. until delivery.

C. Delivery of Samples

During the month of August, all supplies were delivered to the subjects' homes. Frozen samples were packed in dry ice in styrofoam coolers to ensure their frozen state upon delivery. Each mother was provided with three samples of each of the frozen vegetables and one jar of each of the commercially-prepared products. Mothers were instructed to store the commercial products at room temperature and once opened, in the refrigerator. The frozen samples were stored in the freezer until ready to be used. All mothers were supplied with a file folder containing a letter welcoming them to the study (Appendix C), a list of instructions and the necessary forms for recording results.

D. Experimental Plan

1. Schedule for Feeding Vegetables

In the event an allergic reaction to a new food may occur,

it is usually recommended that new foods be introduced to an infant, one at a time, allowing six to seven days before another new food is introduced. On this basis, a six-day cycle for serving each of the vegetables was designed. The entire study took twenty-four days to complete. A schedule (Appendix D) for each of the subjects was designed so no one vegetable was consistently served first or last. The form of vegetable to be served was randomly selected.

2. Instructions for Feeding Vegetables

Upon delivery of samples, mothers received a list of detailed instructions (Appendix E), recommending the size and time of serving, as well as the preparation and storage of vegetables. Approximately thirty minutes was spent with each mother to ensure that the instructions were understood and to stress the importance of recording results. It was recommended that the vegetable be served warm and preferably during the early afternoon feeding. All foods and liquids fed before and after the vegetable for that feeding were recorded. The mothers were informed that the consistency and color of the stools may change upon introduction of a vegetable. Such changes in stool patterns were to be recorded. Mothers were advised not to force the infant to eat. It was also recommended that the mothers do not taste the vegetable first as their reaction may influence the infant or may bias their recordings.

3. Questionnaire

On the first day of the study, all mothers completed a questionnaire (Appendix F) requesting background information on each subject.

4. Recording of Observations

Following each feeding, mothers were instructed to complete an observation sheet (Appendix G). Acceptance or rejection of each vegetable, the approximate amount consumed, and a description of what the infant did to express a like or dislike for that vegetable were among the items to be recorded. A total of twenty-four observation sheets were supplied - one for each feeding situation.

5. Criteria for Measuring Degree of Preference

Since a verbal or written response from the subjects was not feasible, the following criteria were used to measure the degree of preference for each vegetable:

a) the mother's judgment that the infant liked or disliked the vegetable

b) the description of gustofacial responses coupled with physical movements as written by the mother.

6. Pretest of Research Instrument

A pretest of the research instruments was conducted on four infants ranging in age from three to five months. These were infants

whose mothers attended the St. Boniface Hospital Prenatal Clinic and who had no previous exposure to vegetables. Only one vegetable was used for each infant and the pretest was completed in six days. Mothers reported no difficulties with the questionnaire, following the instructions, adhering to the feeding schedule nor in recording results on the observation sheets.

E. Collection of Data

1. Collection of Results

Because the mothers were free to introduce vegetables whenever they wished, the entire study took four months to complete. Mothers were requested to call the researcher when all their samples had been evaluated. The researcher visited each home to collect the results. At this time, the observation sheets were reviewed with each mother to ensure the datawere interpreted accurately.

2. Determination of Preference Scores

The responses of the subjects, as recorded by the mothers, were classified into the following numerical categories:

6 = not fed

5 = obviously likes

4 = seems to like

3 = indifferent

2 = seems to dislike

1 = obviously dislikes

The results were categorized by a team of three judges working independently of one another. Discrepancies were discussed as a group and the variance resolved so that all judges were in agreement with each score.

The basis for placing a response in a particular category was defined as follows:

(6) vegetable not fed

(5) obviously liked

If the infant ate all that was offered and showed fully positive signs of enjoyment:

- smiling, happy, contented
- waving of arms and legs
- opened mouth willingly
- impatient for next spoon
- pulled spoon towards mouth
- ate enthusiastically

(4) seemed to like

If the infant ate some or all that was offered but displayed no obvious signs of enjoyment:

- ate without fussing
- mother's recording of "seems to like"
- not as enthusiastic, but no negative signs

(3) indifferent

If the mother stated she was unable to tell whether the infant liked the vegetable or not. In some cases, the description was vague

and included both negative and positive reactions.

(2) seemed to dislike

If the infant ate some or all, but with some negative reactions:

- frowned
- made faces
- cried and fussed
- would not swallow
- mother's recording of "does not seem to like"

(1) obviously dislikes

If the infant totally rejected the vegetable or ate a small amount with obvious signs of dislike:

- spit out
- refused to swallow
- made faces - frowned, grimaced
- refused to open mouth
- cried and fussed
- pushed spoon away

If the infant was sick during a feeding, the average score for the other two days was used as the response. If the infant was sick for more than two feedings, the score was omitted. If an infant was sick during a feeding, reacted negatively to the vegetable, but ate the balance of his feeding enthusiastically, a score of two or one was given, depending on the intensity of the reaction.

V TRAINED PANEL EVALUATION OF PURÉED VEGETABLES

Canned and frozen vegetables were evaluated by a trained sensory panel. Sensory quality judgments were made on the sweet, sour and bitter taste intensity for all vegetables. Judgments were made on a variety of textural parameters.

A. Selection of Panel

A six-member panel consisting of graduate and undergraduate students from the Faculty of Home Economics, University of Manitoba, was selected from a total of twelve students. All potential panelists had some degree of experience in the area of sensory evaluation. The panelists were selected on their ability to identify mild solutions of the four basic tastes and their ability to rank varied concentrations of different taste solutions. As part of the preselection process, panelists evaluated the vegetable samples according to their flavor and textural characteristics. Their ability to detect and describe these characteristics was also considered in the selection process. All potential panelists were eager to participate and expressed interest in the project.

B. Training of Panel

1. Environment and Duration

All training sessions were conducted in the Foods and Nutrition Laboratory in the Faculty of Home Economics, University of Manitoba. Panelists were seated at a large table to facilitate panel discussion. Panelists met for eight one-hour sessions over a period of three weeks.

2. Magnitude Estimation

Magnitude estimation, a ratio scaling technique, was used as the measuring instrument for the majority of the sensory evaluation. Basically, this technique involves assigning a reference sample a certain score and scaling the samples of interest against the reference. For example, when evaluating the sweetness of vegetables, panelists were provided with a reference sucrose solution. The reference was assigned a score of twenty. If the sweetness perceived in a vegetable was half as sweet as the reference, it was given a score of ten. If the vegetable was twice as sweet, it received a score of forty. Panelists were familiar with magnitude estimation, therefore, only a brief discussion on the concept of ratios as it applies to sensory perception was given.

3. Taste Component

Panelists were trained to identify the taste components of the vegetables and to scale their intensity. Intensities were scaled according to reference solutions of the basic tastes.

4. Textural Component

Panelists analyzed the textural characteristics of the vegetables. They practised scaling the various degrees of a texture characteristic in relation to a reference vegetable. Training continued until panelists gave relatively consistent responses.

5. Results

Scores for both taste and texture training sessions were discussed in a group to ensure that all panelists were perceiving in the same direction. Panelists' scores were recorded from one session to another and examined for consistencies. At the conclusion of the training session, all panelists understood the method of magnitude estimation and were consistent in evaluating the sensory characteristics used in this study.

C. Testing Procedure

1. Taste Panel Environment

The samples were evaluated in a sound-proof, humidity-controlled sensory room. Red lights were used to prevent color from playing

a role in the panelists' judgments. The panels were conducted in the early afternoon and panelists were instructed not to eat lunch until after each session was completed.

2. Preparation and Serving of Samples

The frozen samples were prepared in the same manner as that used for the infant study. They were prepared several months prior to the training and were stored at -25°C. in three-quarter ounce plastic portion cups. The canned vegetables were placed in identical cups. All samples were covered and coded with randomly selected three digit numbers. The order of serving was also randomly selected. To allow for adequate heat penetration, samples were placed in water baths on warming trays, thirty minutes before panelists were due to arrive and were heated to a temperature of 55°C.

In addition to the samples, each panelist received a tray with three reference taste solutions, a reference vegetable for each of the texture parameters, appropriate ballots (Appendix H and I) and other necessary items. Tap-distilled water was available for rinsing and unsalted soda crackers were also available. No group discussion followed these sessions.

3. Taste Intensity Evaluation

All vegetables were assessed according to the degree of sweetness perceived in relation to a reference solution of two percent sucrose (weight by volume in tap-distilled water). Only those vegetables

which were found to contain some degree of sourness or bitterness were evaluated for these characteristics.

Thus, canned peas, canned carrots and canned beans were evaluated for intensity of sourness. These were compared to a 0.01% citric acid solution (weight by volume in tap-distilled water). Excluding frozen peas and canned corn, all other vegetables were evaluated for bitterness. The reference for bitterness was a 0.09% caffeine solution (weight by volume in tap-distilled water).

4. Texture Evaluation

All vegetables were evaluated for viscosity and dryness. Peas and corn were evaluated for chalkiness, mouthcoat and adhesiveness. Carrots and beans were evaluated for pulpiness only, as the aforementioned characteristics were absent from these vegetables. The reference sample for each characteristic was one of the vegetable samples which represented a good example of that characteristic.

5. Degree of Pleasantness of Vegetables and Reference Solutions

Panelists were instructed to rate the degree of pleasantness for each of the reference taste solutions and for each of the vegetable samples. These judgments were based on a nine-point category scale (Appendix J and K).

6. Intensity of Overall Flavor

Panelists were instructed to rate the degree of overall flavor intensity for each of the vegetable samples, utilizing a nine-point category scale (Appendix L).

7. Intensity of Vegetable Flavor

The intensity of vegetable flavor for each sample was judged using the same scale as mentioned above (Appendix M).

8. Power Functions

i) Stimuli

In order to derive a power function for each of the three tastes considered in this study, panelists were instructed to assign ratios to a series of concentrations of sweet, sour and bitter stimuli. The concentrations used are found in Appendix N. In each case, the reference solution was the same concentration as that used in the taste intensity evaluation.

ii) Order of Serving

The order of serving was randomly selected except for the two highest concentrations of each stimuli. To avoid fatigue, these samples were tasted last. Panelists tasted the sweet stimuli first, followed by the sour stimuli. The bitter stimuli was evaluated last. Panelists were instructed to rest between samples. Following the completion of each set of stimuli, they were instructed to take a

ten minute break before beginning the next set. Appropriate ballots (Appendix O) were used.

VI ANALYSIS OF DATA

All data from the taste intensity and texture evaluation tests were analyzed using a Factorial Analysis of Variance and Duncan's Multiple Range Test. Linear regression was used to determine the power function for each of the sweet, sour and bitter stimuli.

RESULTS AND DISCUSSION

Following a report on the description of the sample, the findings related to infant vegetable preference and the sensory analysis of these vegetables will be presented. The relationship between vegetable preference and sensory characteristics will be discussed.

I DESCRIPTION OF SAMPLE

A. Size of Sample

Of the initial fifty mothers who volunteered to have their infants participate in this study, only forty-three (eighty-six percent) completed reports were obtained. This decrease in sample size was due to several factors. One family left Winnipeg; three infants became ill prior to the study; one physician recommended commercially-prepared vegetables not be used; and one mother decided to breast-feed beyond the study period. Failure by one mother to follow instructions resulted in the loss of another subject. As a result, data from forty-three completed questionnaires regarding current infant feeding practices are reported.

The sample consisted of twenty-four males and nineteen females ranging in age from six to nineteen weeks. With the exception of one premature infant, all subjects were healthy, full-term infants.

On the first day of the study, mothers completed a

questionnaire (Appendix F) which requested information on the subject's past feeding experiences. Completed questionnaires from forty-three mothers provide information on the type of milk fed at birth, milk presently used, and the age of introduction to solids. As the sample was not selected randomly and the majority of mothers had attended the prenatal clinic, the extent to which the findings in this study reflect current practice is uncertain.

Mothers were also asked to indicate their infants' preferences for a variety of solids. It should be noted here that these preferences are merely those perceived by the mothers and should not be taken as definite likes and dislikes. While the results relating to likes and dislikes are written as such, they should be thought of as "perceived to prefer" or "perceived to dislike."

B. Types of Milk

1. Birth Milk

Almost seventy-five percent of the subjects were breast-fed at birth (Table 1.1). Ten infants (23.2%) were fed a commercial milk formula. Two infants were fed both breast milk and commercial formula. This information contrasts sharply with previous research. From 1950 to 1960, the incidence of breast-feeding in the United States declined. One in four infants was breast-fed upon leaving the hospital while the remaining seventy-five percent received

Table 1.1

Description of Sample by Milk Fed at Birth

(N = 43)

Type of Milk	Number	Percentage
Breast	31	72.1%
Breast/Commercial Formula	2	4.6%
Commercial Formula *	10	23.2%

* Similac, Enfalac

prepared formula (Rivera, 1971). It has recently been estimated that twenty percent of infants less than one month of age are breast-fed in the United States (Fomon, 1975). Perhaps the large number of infants being breast-fed in this study reflects a trend towards increased interest in breast-feeding.

2. Present Milk

A variety of milk was fed to the subjects at the time of the study (Table 1.2). Of those subjects breast-fed at birth, only five (11%) were still receiving breast milk. Eight infants were in the process of being weaned, two to a commercial formula and six to two percent milk. In the past, most of the fresh cow's milk fed to infants was whole milk, but two percent and skim milk are also used now (Fomon, 1975). Of particular interest here, is the large percentage (39.5%) of infants receiving two percent milk compared to those infants (5%) receiving whole milk. None of the subjects was consuming skim milk. By combining the percentage of infants being weaned on two percent milk, the total number of infants on low-fat milk rises to twenty-three (53.5%). The popularity of using two percent milk in this study contrasts sharply with that reported by Harris and Chan (1969). Approximately sixty percent of three hundred and eighty-three infants were taking whole cow's milk at four months of age. Perhaps the increasing use of two percent milk in this study reflects the current concern over infant obesity.

Table 1.2

Description of Sample by Milk Fed at Present* Time

(N = 43)

Type of Milk	Number	Percentage
Breast	5	11.6%
Whole	2	4.7%
Two Percent	17	39.5%
Commercial Formula	11	25.6%
Breast/Commercial Formula	2	4.7%
Breast/Two Percent Milk	6	14.0%

* At introduction to vegetables

C. Introduction to Non-Milk Foods

1. Fruit Juice

The ages at which subjects were introduced to fruit juices can be seen in Table 1.3. Ten subjects did not receive fruit juice. Of those subjects receiving juice, almost ninety percent had tasted juice at less than three months of age. Considering the entire sample (N=43), approximately seventy percent had consumed fruit juice before three months of age. Maslansky's (1971) dietary analysis of four hundred and fifty-one infants revealed forty percent were fed fruit juice by three months of age.

Apple juice was most frequently served first (51.5%) followed by orange juice (36.4%) and prune juice (9.1%).

Mothers reported on their infants' preference for fruit juice. Table 1.4 shows the types of fruit juices served and of these juices, which were reported to be preferred or disliked by the subjects. It appears that apple juice was most popular, followed by orange juice. Apple juice was served to twenty-six infants. Of these, fourteen infants preferred it and five disliked it compared to other fruit juices. Seven of seventeen infants receiving orange juice preferred it, while three disliked it. Prune juice was served to five infants, preferred by none and disliked by two infants. Grapefruit juice was disliked by one of the two infants who received it. No preference or dislike was reported for five infants receiving pear or pineapple juice. The findings of this study are

Table 1.3

Description of Sample by Age of Introduction to Fruit Juice

Age	Number	% N=33	Cumulative % N=33	% N-43	Cumulative % N=43
< 4 weeks	5	15.2	15.2	11.6	11.6
4 < 8 weeks	8	24.2	39.4	18.6	30.2
8 < 12 weeks	16	48.5	87.9	37.2	67.4
12 weeks and over	4	12.1	100.0	9.3	76.7
No Juice	10			23.3	100.0

Table 1.4

Description of Sample by Preference for Fruit Juice

(N = 33)

Type of Juice	Had	Prefer	Dislike
Grapefruit	2	-	1
Prune	5	-	2
Orange	17	7	3
Apple	26	14	5
Pineapple	4	-	-
Pear	1	-	-
Other *	3	1	-

* Mixed Fruit Juice

comparable to those of Maslansky et al (1971). Both apple and orange juice were most preferred, although the order of preference was reversed.

2. Cereal

Cereal was consistently reported to be the first solid food introduced into the infant's diet. Only one infant had not received cereal prior to the introduction of vegetables. The age of introduction to cereals can be seen in Table 1.5. An early introduction to cereals was reported. Forty percent received cereal at less than four weeks of age. Almost eighty percent were consuming cereal under eight weeks of age. Harris and Chan (1969) reported that eighty percent received cereals by one month of age. In 1955, Beal (1957) found that infants were introduced to cereal at one month of age. The findings of this study reveal cereals are introduced at a later age than in the past. However, this is not in agreement with current recommended feeding practices. In 1976, the Manitoba Department of Health and Social Development in conjunction with the Manitoba Medical Association recommended that cereals be introduced at three months (Manitoba, 1976).

In this study, almost sixty percent of the thirty-three infants under eight weeks of age were reported to like cereal when first offered. The degree of acceptance was higher than that reported by Beal (1957). Of thirty-seven infants given cereal by two months of age, only thirty-two percent readily accepted it

Table 1.5

Description of Sample by Age of Introduction to Cereal

Age	Number	% N=42	Cumulative % N=42	% N=43	Cumulative % N-43
< 4 weeks	18	42.9	42.9	41.8	41.8
4 < 8 weeks	15	35.7	78.6	34.9	76.7
8 < 12 weeks	4	9.5	88.1	9.3	86.0
12 weeks and over	5	11.9	100.0	11.6	97.6
No Cereal	1			2.4	100.0

when first offered. Fourteen subjects disliked cereal and, of these, seven refused to eat it. Only initial reactions of infants to cereal was recorded. No further information was obtained on later acceptance.

3. Fruit

The majority of subjects received fruit prior to the introduction of vegetables. Table 1.6 shows the ages at which fruit was introduced. Only thirteen subjects were fed vegetables before fruit. Less than ten percent of all subjects received fruit before four weeks of age and forty percent before eight weeks. These findings definitely contrast with those of Harris and Chan (1969). These investigators reported fifty percent of infants were offered fruit by one month of age, and eighty-three percent at two months of age. While the age of introduction to fruit in this study is later than that reported in 1969, infants are still being offered fruit at an age earlier than that currently being recommended. It has been recommended that fruit be introduced at four and one-half months of age (Manitoba, 1976). It is also recommended that vegetables be introduced before fruit as infants may develop a preference for the sweet taste of fruit and reject vegetables.

Bananas were the fruit most commonly introduced first, followed by peaches, pears and applesauce. Ninety percent of the subjects were reported to have liked fruit when first offered.

Table 1.6

Description of Sample by Age of Introduction to Fruit

Age	Number	% N=30	Cumulative % N=30	% N=43	Cumulative % N=43
≤ 4 weeks	3	10	10	6.9	6.9
< 8 weeks	14	46.7	56.7	32.6	39.5
8 < 12 weeks	8	26.7	83.4	18.6	58.1
⩾ 12 weeks	5	16.7	100.1	11.6	69.7
No Fruit	13			30.2	100.0

While no subject refused to eat the fruit, only ten percent disliked it. Commercially-prepared fruits were used by seventy-five percent of the mothers in this study. A high degree of acceptance for fruit has been reported by other investigators (Beal, 1957; Guthrie, 1966; Harris et al, 1969; and Maslansky et al, 1971).

The mothers reported on the types of fruit served and which fruit was most preferred and which was disliked (Table 1.7). Bananas appear to be most preferred, followed by pears and applesauce. Peaches, apricots and prunes were most often disliked.

4. Meat

The majority of infants had not been introduced to meat at the time of the study. Only four infants, all less than three and one-half months of age, received meat. The mothers of three infants reported following the advice of their physicians regarding the introduction of solids. This procedure is not compatible with current recommendations of introducing meat at six months of age (Manitoba, 1976). Mothers reported that only one infant liked the meat when first offered. Other researchers have reported that meat is not willingly accepted by most infants (Beal, 1957; Harris et al, 1969).

Table 1.7

Description of Sample by Preference For Fruit

(N = 30)

Type of Fruit	Had	Prefer	Dislike
Apricot	17	5	4
Peach	25	8	8
Plum	6	2	1
Pineapple	6	3	-
Applesauce	25	10	6
Prune	8	3	3
Pear	27	14	1
Banana	24	18	2

5. Vegetables

Introduction of vegetables was the main interest in this study. Mothers were not advised to introduce vegetables at any particular age. As a result, they were introduced into the subjects' diets at varying ages (Table 1.8). Forty percent of the infants were offered vegetables at less than three months of age. Three infants were fed vegetables as early as six to eight weeks of age. Recommended age of introduction to vegetables is four months (Manitoba, 1976).

Occasionally, problems may occur with the introduction of various food groups into the infant's diet. However, none of the infants in this study exhibited an allergic response to any of the vegetables. Neither the canned nor the frozen vegetables resulted in any serious intestinal discomfort. Four infants suffered from gas and/or constipation after consuming canned or frozen peas. There were two reported cases of gas for each of the canned or frozen beans. While corn is not usually one of the first vegetables introduced into the infant's diet, no harmful effects appeared from doing so. Three infants were reported to have loose stools after eating canned or frozen corn. There is, however, no evidence to indicate that these effects were due solely to the ingestion of these vegetables.

Table 1.8

Description of Sample by Age of Introduction to Vegetables

(N = 43)

Age (Weeks)	Number	%	Cumulative %
6< 8	3	7.0	7.0
8 < 10	7	16.3	23.3
10 < 12	8	18.6	41.9
12 < 14	12	27.9	69.8
14 < 16	6	14.0	83.8
16 < 18	4	9.3	93.1
18 < 20	3	7.0	100.0

6. Basis for Introduction of Solids

Mothers were asked how the time to introduce solids was determined. Approximately forty percent followed the advice of their physician. Twenty percent decided to introduce solids based on personal experience and five percent relied on the advice of relatives and friends. No mother reported her decision stemmed solely from books and magazines, prenatal clinics or public health nurses. Eleven mothers gave multiple answers of the aforementioned and five reported other varied reasons. Harris and Chan (1969) found that the majority of mothers repeatedly introduced foods at an age earlier than that recommended by physicians.

7. Discussion on Age of Introduction to Solids

It appears that infants are still being introduced to solids at a relatively early age. Figure 1 graphically illustrates the ages at which solids and fruit juice were introduced in this study. At less than twelve weeks of age, almost ninety percent of the subjects had received cereal, seventy percent had fruit juices, sixty percent had fruit and forty percent had vegetables.

The age of introduction to solids was five to six months in 1949 and six weeks or less in 1958 (Committee, 1958). Current trends in infant feeding practices over the last fifteen years have not been established. Compared to the practices in 1958, infants in this study received solids at a much later age. However, these findings do not agree with the recommendations set out by the Manitoba

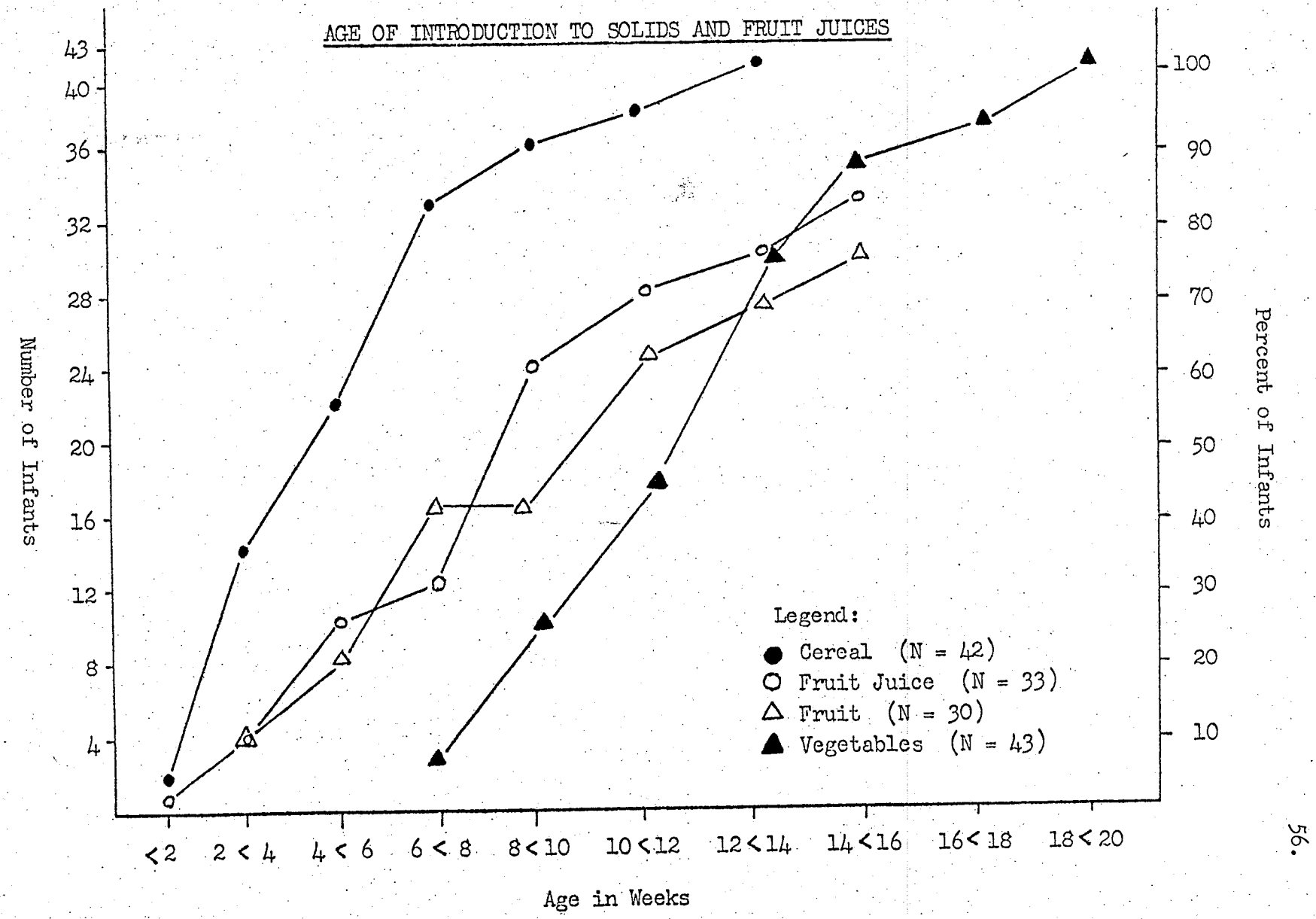

AGE OF INTRODUCTION TO SOLIDS AND FRUIT JUICES
Number of Infants
Percent of Infants
43
40
36
32
28
24
20
16
12
8
4
100
90
80
70
60
50
40
30
20
10
Legend:
Cereal (N = 42)
Fruit Juice (N = 33)
Fruit (N = 30)
Vegetables (N = 43)
<2
2 < 4
4 < 6
6 < 8
8 < 10
10 < 12
12 < 14
14 < 16
16 < 18
18 < 20
Age in Weeks

Figure 1

Department of Health and Social Development in 1976. Anderson and Fomon (1974) recommend that up to six months of age, there is an adequate intake of all essential nutrients without solids. It seems, therefore, that solids are still being introduced earlier than what is nutritionally necessary.

D. Vegetable Preference Scores

Each vegetable was fed for three consecutive days, hence there are three preference scores for each vegetable. The scores range from one which represents "obviously dislikes" to five for "obviously likes". A score of three signifies indifference. The technique used to determine vegetable preference has been discussed earlier (page 30).

The following abbreviations have been used in the graphs and tables:

cnd pref	=	canned preference
frz pref	=	frozen preference
ccrt	=	canned carrots
fcrt	=	frozen carrots
cpea	=	canned peas
fpea	=	frozen peas
cbns	=	canned beans
fbns	=	frozen beans
ccrn	=	canned corn
fcrn	=	frozen corn

1. Comparison of Consistent and Inconsistent Scores

A comparison of the "consistently like" scores for each vegetable is displayed in Figure 2. That is, those vegetables which received a score of four or five on all three days. Canned corn had the highest percentage of "consistently like" scores (57.9%) while both frozen and canned beans had the lowest (39.5%).

A comparison of those vegetables "consistently disliked" on all three days is shown in Figure 3. That is, those vegetables which received a score of one or two on all three days. Almost thirty percent of the subjects consistently disliked frozen beans, followed closely by twenty-seven percent consistently disliking canned carrots. Approximately fifteen percent of the infants consistently disliked all other vegetables.

There were many times when the preference for a vegetable varied from one day to the next. These were termed "inconsistent" scores. A comparison of the vegetables receiving inconsistent scores is shown in Figure 4. Over forty percent of the infants were inconsistent in their preference for canned beans. Less than twenty-five percent of the subjects had inconsistent scores for canned carrots, frozen peas and canned corn.

Only one or two infants remained consistently indifferent to most of the vegetables. Mothers reported they were unable to determine whether the vegetable was liked or disliked. No consistently indifferent scores were found for frozen carrots or canned peas.

COMPARISON OF "CONSISTENTLY LIKE" SCORES (≥ 4)

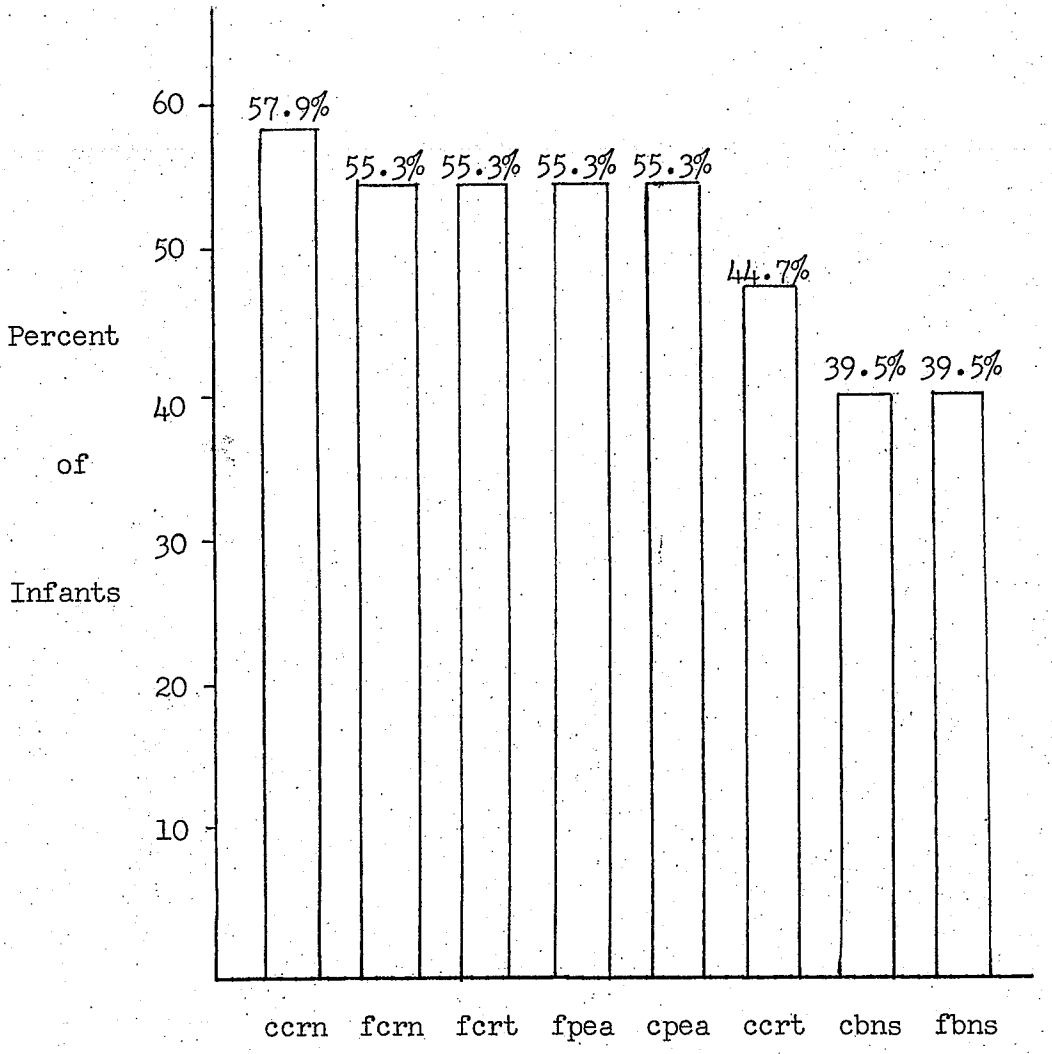


Figure 2

COMPARISON OF "CONSISTENTLY DISLIKE" SCORES (≤ 2)

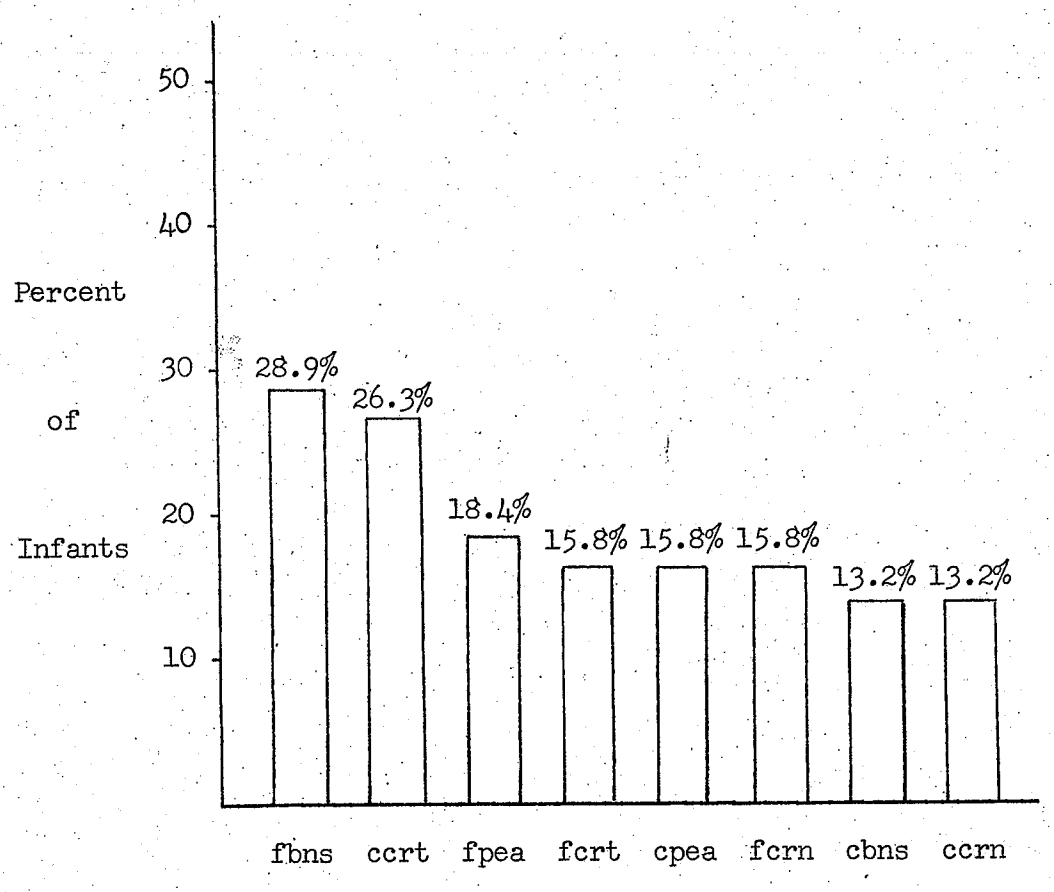


Figure 3

COMPARISON OF INCONSISTENT SCORES

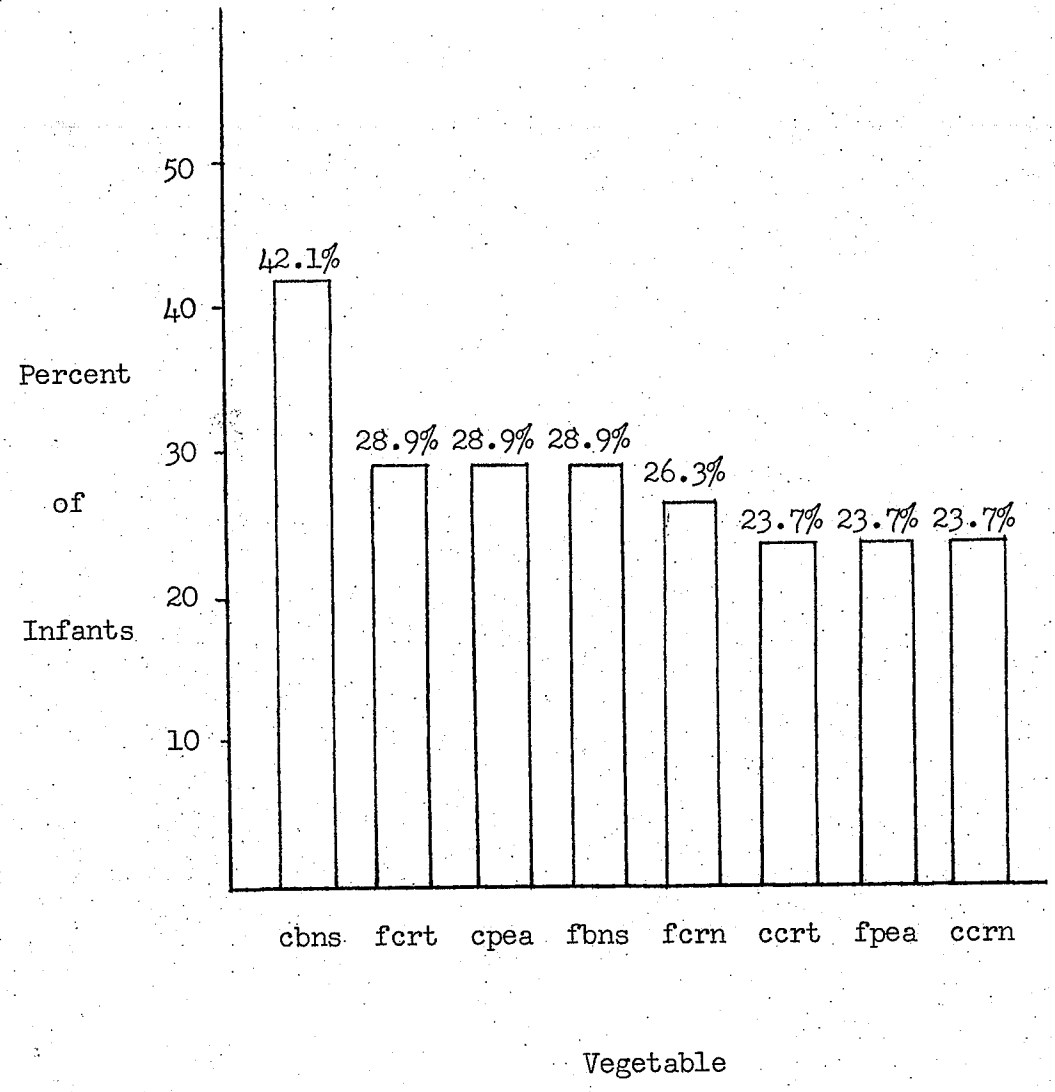


Figure 4

It is interesting to note that canned corn had the highest percentage of "consistently like" scores, and the lowest percentage for "consistently dislike" and "inconsistent" scores. On the other hand, frozen beans had the lowest percentage of "consistently like" scores and the highest for "consistently dislike". Canned carrots followed a similar pattern. Sixteen infants were inconsistent in their preference for canned beans, while approximately nine infants had inconsistent scores for all other vegetables. This suggests that infants were more confused over preference for canned beans. Only one infant was found to consistently like all vegetables when offered, while one was found to dislike all vegetables. Because of these large number of inconsistent scores, it was felt that the trends of possible preference emerging from the statistical analysis should be acknowledged and treated with some consideration.

From Table 2, it can be seen that canned carrots, canned beans and frozen beans were "obviously liked" by five or less infants. (i.e. scores of five for all three days). More than three times as many infants obviously liked frozen corn and frozen carrots compared to the aforementioned vegetables. Canned carrots were obviously disliked by seven infants (i.e. scores of one for all three days). No infant obviously disliked canned corn on all three days.

Table 2

Number of Infants Who Obviously Liked* or Obviously Disliked** Each Vegetable

Vegetable	Obviously Liked	Obviously Disliked
ccrt	5	7
fcrt	14	4
cpea	10	2
fpea	11	4
cbns	3	1
fbns	4	4
ccrn	12	0
fcrn	15	2

* Preference score of 5 for all three days

** Preference score of 1 for all three days

2. Comparison of Preference Scores on First and Last Day of Feeding

Table 3 shows the number of infants who liked or disliked a vegetable the first time served, but did not do so on other feedings. Also shown here is the number of infants who liked or disliked a vegetable on the last feeding but displayed an opposite preference on the first two feedings. Very few of the infants liked a vegetable the first time offered, and disliked it on subsequent feedings. This occurred with three infants when fed canned beans and with two infants when fed frozen carrots, canned peas and canned corn. Slightly more subjects disliked a particular vegetable the first time offered, but liked it on the next two feedings. Six subjects reacted in this manner with canned beans and five with frozen carrots. No infants were found to dislike canned carrots or frozen beans on the first day, and like it on subsequent feedings. Three or four infants liked frozen beans, frozen peas and canned peas the last time served, but not on previous feedings. This suggests that perhaps some vegetables were more acceptable as the infant became more familiar with it. Infants did not seem to tire of eating the same vegetable three days in a row. Only one infant disliked frozen peas and one disliked canned beans on the last day served. On previous feedings, these vegetables were liked.

Table 3

Number of Infants Who Changed Preference Scores

On First and Last Day of Feeding

Vegetable	Liked First Day Not Others	Disliked First Day Not Others	Liked Last Day Not Others	Disliked Last Day Not Others
ccrt	0	0	1	0
fcrt	2	5	1	0
cpea	2	2	4	0
fpea	0	2	3	1
cbns	3	6	0	1
fbns	1	0	3	0
ccrn	2	2	0	0
fcrn	0	2	1	0

3. Infant Expressions of Preference

The manner in which an infant expresses his food preferences has met with little attention in the literature. The findings of this study indicate that infants do have vegetable preferences. However, it appears that infants, like adults, are individuals with individual preferences. Some of the commonly cited expressions of preference as reported by mothers in this study are as follows:

Positive expressions:

- "ate enthusiastically, pulling spoon towards him"
- "eagerly opens mouth for next spoonful"
- "angry if not fed fast enough"
- "smiled and cooed throughout feeding"
- "happy, content, ate willingly"

Negative expressions:

- "spit it all out"
- "refused to open mouth after first taste"
- "scowled and grimaced"
- "blinked rapidly, shivered, and eyes started to tear"
- "closed eyes and made angry faces"
- "pushed my hand away and backed away from spoon"

E. The Measurement Tool

The measurement tool used in this study was insensitive to measuring the "degree" of preference. However, for approximately seventy-five percent of the infants, it was clearly possible to determine a like or dislike for the majority of vegetables.

The large number of inconsistent scores in this study exemplify the difficulties involved in obtaining information on infant vegetable preferences. There are a number of uncontrollable factors involved in a study of this type. An infant who is extremely hungry may consume the vegetable willingly, only to refuse it the next day if his hunger is not as great. Similarly, a hungry infant may reject the offered vegetable because he only wants milk to satisfy his hunger. If the infant was sick, fussy or discontent on one day, the vegetable may be refused, but accepted the following day.

The measurement tool was also vulnerable to a variety of uncontrollable factors. The recording of results was the sole responsibility of the mothers. Due to time and financial restraints, it was impossible to have outside observers record each infant's reaction to the vegetables for twenty-four days. Because mothers are so familiar with their infants, it was felt that they would be the best judge of preference. However, this situation may lend itself to a certain amount of bias. The present concern over the addition of salt, sugar and other additives to commercially strained infant food may have biased some mothers against the canned

vegetables. The preparation and ingredients involved in the vegetables used were not divulged. Mothers were merely informed as to the identity of each vegetable. However, because of the packaging, it was easy to determine that the canned vegetable was a commercial product. It was recommended that the mothers did not taste the samples, to avoid consciously or unconsciously influencing the infant, particularly if the mother found the vegetable unacceptable. It is not known how many mothers complied with this recommendation. A mother's personal preference for a vegetable may have biased her observations and recordings. One mother reported that the reason her infant disliked peas was probably because she didn't like them either. Similarly, one mother reported that corn was her favourite vegetable so it wasn't surprising that her infant liked it also. Maternal pride concerning the acceptance of vegetables may also be a factor involved (Butler et al, 1954; Guthrie, 1966). Acceptance of vegetables may be seen by some mothers as a sign of achievement. One mother whose infant disliked all vegetables was extremely upset over this rejection. Several mothers proudly declared their infants' love for the majority of vegetables.

The mother's degree of interest in the study was reflected in part by the information conveyed on the observation sheets. Those mothers who appeared extremely interested in the study provided vivid description, while others, who may have been less interested, were less verbose. Some mothers may have been more perceptive in observing infant reactions. The ability to write and communicate effectively

was undoubtedly a factor in recording results. Several mothers suggested it would have been easier to have a list of reactions to check against rather than describe them themselves. It is also possible that a "halo" effect may have existed in the recording of results. Mothers were asked to complete each observation sheet immediately after each feeding. If these sheets were not completed daily, but perhaps completed after several days, the mother may have assumed that reactions were similar to the last recorded reaction. Hence, important information may have been omitted.

II SUMMARY OF ANALYSIS OF INFANT VEGETABLE PREFERENCES AND SENSORY EVALUATION OF PURÉED VEGETABLES

To assist the reader in understanding the data analyses, Table 4 represents a brief summary of the way in which the data were analyzed. Infant vegetable preference was determined by analyzing the data in three separate ways. A trained panel evaluated the sensory characteristics of all vegetables according to the parameters outlined in this table. The relationship between those vegetables preferred or less preferred by infants and the sensory characteristics of these vegetables will be discussed in subsequent sections.

III INFANT VEGETABLE PREFERENCES

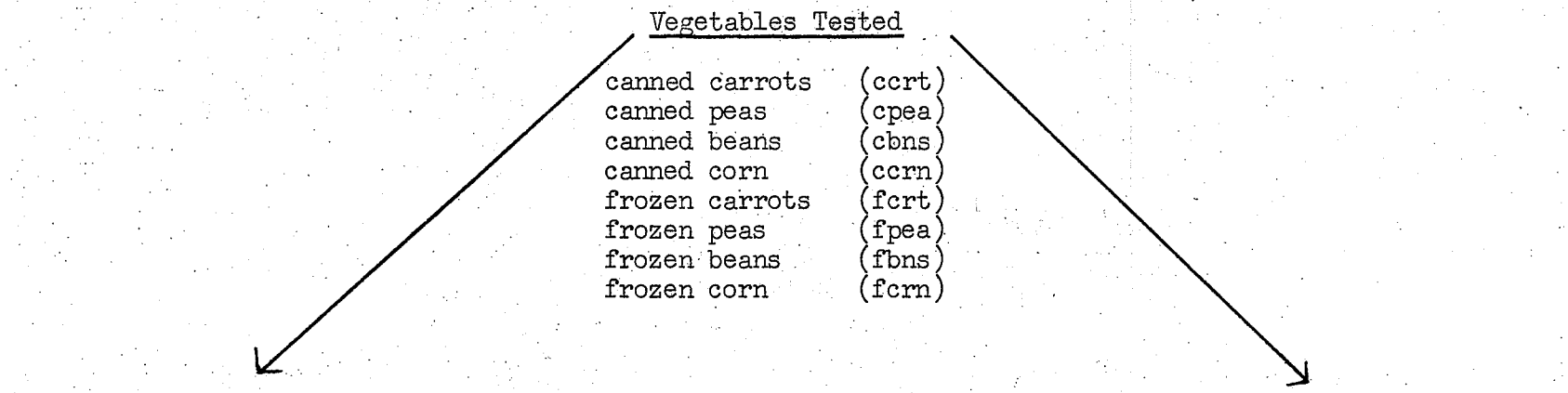
A. Analysis of Preference Scores

1. Size of Sample

The data from thirty-eight subjects were analyzed for vegetable preference. The results from five of the subjects were discarded because the infants were not fed one or more of the vegetables.

Table 4

Summary of Analysis of Infant Preferences and Sensory Evaluation of Puréed Vegetables



I Infant Vegetable Preference

Analysis

1. All Subjects

2. Age Groups
   - AGE 1 (< 10 weeks)
   - AGE 2 ($10 < 16$ weeks)
   - AGE 3 (≥ 16 weeks)

3. Feeding Regime
   - VEG 1 (fed vegetables first)
   - VEG 2 (fed fruit first)

II Trained Adult Panel Sensory Evaluation

Taste Intensities: Sweetness, Sourness, Bitterness

Texture Characteristics: Viscosity, Dryness, Mouthcoat, Adhesiveness, Chalkiness, Pulpiness

Intensity of Overall Flavor
Intensity of Vegetable Flavor
Degree of Pleasantness

2. Analysis of Results

Results were analyzed in three different ways. The initial analysis included all thirty-eight subjects. To test the effect due to age, subjects were divided into three age groups. The effect due to previous feeding regime was tested by dividing the subjects into two groups - those fed vegetables first and those fed fruit before vegetables. The hypotheses tested in each of these categories will be shown with an accompanying table of the findings. Differences in preference were determined at the five percent level of significance. Probability levels of less than 0.20 are also shown in the tables as they may be indicative of trends in preference. For those hypotheses where a large number of variables are analyzed, only those variables with probabilities of less than 0.20 are listed.

3. Discussion of Non-parametric Statistics

The data were analyzed using a variety of non-parametric statistics. The sample was not randomly selected and the majority of mothers had attended the pre-natal clinic. The extent to which these preferences reflect those of the infant population in general is uncertain. Infant vegetable preferences were based on a one to five category scale. Thus the data were of an ordinal nature and were not amenable to parametric statistical analyses. A brief discussion of the non-parametric statistics used in this study is given below.

Wilcoxon Matched-Pairs Signed-Rank Test:

This test is a non-parametric t-test employing two related groups (Siegal, 1956). It takes into consideration the magnitude of the difference between two scores. All difference scores are ranked in order of their absolute value. Each rank is assigned the sign of the difference score. If the null hypothesis is true, the sum of the positive ranks and the sum of the negative ranks should be about equal. Significance is determined by comparing the calculated value of "z" with those found in a table of probabilities for values of "z" in the normal distribution.

An example of how this statistic is used can be seen in Table 6.1. The difference scores for frozen corn minus frozen beans was twenty for the positive ranks and eleven for the negative ranks. This means that twenty infants preferred frozen corn over frozen beans, and only eleven infants had a greater preference for frozen beans over frozen corn. Therefore, frozen corn is the preferred vegetable.

Mann-Whitney U Test:

This is a non-parametric t-test employing two independent groups (Siegal, 1956). Scores from both groups are combined and ranked with each score's identity being maintained. The statistic U is given by the number of times a score in group B precedes a score in group A. The greater of the two mean ranks indicates the vegetables which received the higher scores. Significance is determined by comparing the calculated value of U with those found

in the table of critical values of U in the Mann-Whitney Test.

Friedman Analysis of Variance:

This test employs more than two related samples (Siegal, 1956). Scores in each row are ranked separately and these ranks constitute the data of the test. The ranks for each column are totalled, and if these are about equal, the null hypothesis is accepted. Significance is determined by comparing the calculated chi square with those found in a table of critical values for chi square. The mean ranks indicate the order of preference with the greatest mean rank representing the higher scores.

Kruskall-Wallis Analysis of Variance:

This test employs more than two independent samples (Siegal, 1956). All scores are ranked together and the ranks for each group are totalled. If the null hypothesis is true, there will be little difference between rank totals from one group to another and consequently little difference between the mean ranks. Significance is determined by comparing the calculated chi square statistic to those found in a table of critical values for chi square. As above, the mean ranks indicate the order of preference.

B. Vegetable Preference by All Subjects

1. Overall Assessment

Each vegetable was served for three consecutive days. As explained earlier, (page 30) judges assigned a preference score for

each day, based on the mother's written description of the infant's reaction to each feeding. The infant's mean preference score for each vegetable was calculated and this constituted the data used in the statistical analysis. The mean scores for preference by all subjects may be seen in Table 5. These scores represent an overall assessment of vegetable preference by infants in this study. Little difference in preference exists for either the canned or frozen form. The most favoured vegetable, without regard to form, was corn while the least favoured was beans. Both the canned and frozen corn had the highest mean preference score, while frozen beans had the lowest, followed closely by canned carrots.

2. Test Hypotheses I

The first series of hypotheses tested involved all thirty-eight subjects.

(a) Infants exhibit the same preference for all canned vegetables as they do for all frozen vegetables.

As shown in Table 6.1, no significant differences in preference were found. The null hypothesis was accepted.

(b) Infants exhibit the same preference for the canned and frozen form of each vegetable.

The null hypothesis was accepted as no significant differences in preference were found (Table 6.2).

It is interesting to notice two possible trends which arise from this analysis. It appears that frozen carrots may be preferred over

Table 5

Mean Preference Scores for All Vegetables and Form by All Subjects

N = 38

Form	Vegetable (Disregarding Form)	Vegetable (Regarding Form)
cnd = 3.47	bns = 3.21	fbns = 3.12
frz = 3.56	crt = 3.44	ccrt = 3.16
	pea = 3.62	cbns = 3.42
	crn = 3.74	cpea = 3.57
		fpea = 3.66
		fcrt = 3.71
		ccrn = 3.73
		fcrn = 3.76

Category Response:

1 = obviously dislikes

2 = seems to dislike

3 = indifferent

4 = seems to like

5 = obviously likes

Table 6.1

Preference for Canned vs Frozen Vegetables by All Subjects

N = 38

Wilcoxon Matched-Pairs Signed-Rank Test

	- Ranks	+ Ranks	z	Probability
Frz Pref - Cnd Pref	14	22	-0.880	n.s.

Table 6.2

Preference for Canned and Frozen Form of Each Vegetable by All Subjects

N = 38

Wilcoxon Matched-Pairs Signed-Rank Test

	- Ranks	+ Ranks	z	Probability
fcrt - ccrt	8	20	-1.844	n.s. (< 0.20)
fpea - cpea	13	16	-0.616	n.s.
cbns - fbns	11	17	-1.321	n.s. (< 0.20)
fcrn - ccrn	14	12	-0.267	n.s.

canned carrots and canned beans preferred over frozen beans.

(c) Infants exhibit the same preference for all vegetables in the canned form and for all vegetables in the frozen form.

The null hypothesis was accepted as no significant differences in preference were found (Table 6.3).

It can be seen that the highest mean rank for the canned vegetables was canned corn at 2.70 and the lowest mean rank was 2.33 for canned carrots. This suggests that canned corn may be more preferred than canned carrots. The highest mean rank for frozen vegetables was 2.70 for frozen carrots and 2.09 for frozen beans. This suggests that frozen beans were less preferred than frozen carrots.

(d) Infants exhibit the same preference for one vegetable as they do for another (i.e. using all possible combinations of vegetables and form).

The null hypothesis was rejected three times out of twenty-eight individual comparisons. Frozen beans were significantly less preferred than canned corn, frozen carrots and frozen corn.

Table 6.4 describes only those vegetable pairs where suggested and significant preferences were found. It can be seen that frozen beans may be less preferred than canned peas, canned beans and frozen peas. The data also suggest that canned corn, frozen corn, frozen peas and frozen carrots may be more preferred than canned carrots. This lower preference for canned carrots is interesting in that carrots have been reported to be more preferred by other

Table 6.3

Preference for Canned Vegetables and For Frozen Vegetables by All Subjects

N = 38

Friedman Analysis of Variance

Vegetable	Mean Rank	Chi Square	d f	Probability
ccrt	2.33	1.760	3	n.s.
cpea	2.55			
cbns	2.42			
ccrn	2.70			
fcrt	2.70	5.218	3	
fpea	2.58			n.s. (< 0.20)
fbns	2.09			
fcrn	2.63			

Table 6.4

Preference for Selected Vegetable Pairs by All Subjects

N = 38

Wilcoxon Matched-Pairs Signed-Rank Test

Vegetables	- Ranks	+ Ranks	z	Probability Significant (≤ 0.05)	Trends (< 0.20)
ccrn - ccrt	11	19	-1.625		n.s.
fcrt - ccrt	8	20	-1.844		n.s.
fpea - ccrt	12	21	-1.304		n.s.
fcrn - ccrt	12	21	-1.528		n.s.
cpea - fbns	11	22	-1.519		n.s.
cbns - fbns	11	17			n.s.
ccrn - fbns	9	22	-2.303	0.021	
fcrt - fbns	9	21	-2.396	0.017	
fpea - fbns	9	19	-1.913		n.s.
fcrn - fbns	11	20	-1.969	0.049	

investigators (Martin Du Pan, 1955; Harris et al, 1969; Maslansky et al, 1974).

3. Summary Discussion

The null hypotheses were accepted in all cases except for three. The findings indicate that infants exhibit a significant preference for canned corn, frozen carrots and frozen corn over frozen beans. Analyses of the data indicate certain trends in preference may be operating. Canned peas, canned beans and frozen peas may be more preferred than frozen beans. A trend in lower preference for canned carrots occurs often. This suggests that frozen carrots, frozen peas, canned corn and frozen corn may be more preferable to infants than canned carrots. Under these circumstances, it appears that canned corn, frozen peas, frozen carrots and frozen corn are most preferred as these are the vegetables which emerge in both the trend and significant results. Similarly, frozen beans and canned carrots emerge as the least preferred vegetables.

C. Effect of Age on Vegetable Preference

The subjects were divided into three age groups. AGE 1 consisted of nine subjects less than ten weeks of age, AGE 2 involved twenty-two subjects from ten weeks to less than sixteen weeks, and AGE 3 had seven subjects who were sixteen weeks of age

and older.

1. Overall Assessment

In all age groups, the mean preference score for the canned form of vegetable was less than that for the frozen form (Table 7.1). The mean score for the canned form was similar across all three age groups. The frozen score for the older infants was much greater than those for the younger infants. It was also larger than the canned score for this group. It appears older infants may prefer the frozen vegetables more than the canned vegetables, and also may prefer frozen vegetables more than younger infants.

Infant preference for individual vegetables without regard to form is shown in Table 7.2. The AGE 1 group had the highest preference score for carrots, while both AGE 2 and AGE 3 groups scored highest for corn. It is interesting to note that corn was tied with beans for lowest preference score in AGE 1. In all three age groups, beans received the lowest preference score.

Infant vegetable preference appears to change with age. In Table 7.3 the youngest infants appear to prefer frozen carrots and frozen peas most. Infants aged ten weeks and less than sixteen weeks prefer both forms of corn most, followed closely by frozen carrots. For the oldest infant, frozen carrots appear to be liked, but not as well as frozen peas and both types of corn. Frozen beans were the least liked vegetable for all age groups. AGE 1 infants liked corn less than did the other two groups. AGE 2 and AGE 3 infants

Table 7.1

Comparison of Mean Preference Scores* For Canned vs Frozen Vegetables by Age

Form of Vegetable	AGE 1 (< 10 weeks)	AGE 2 (10 < 16 weeks)	AGE 3 (≥ 16 weeks)
	N = 9	N = 22	N = 7
Cnd Pref	3.42	3.50	3.49
Frz Pref	3.55	3.51	3.81

* Category Response:

1 = obviously dislikes

2 = seems to dislike

3 = indifferent

4 = seems to like

5 = obviously likes

Table 7.2

Comparison of Mean Preference Scores* For Each Vegetable (Disregarding Form) By Age

Vegetable	AGE 1 (< 10 weeks) N = 9	AGE 2 (10 < 16 weeks) N = 22	AGE 3 (⩾ 16 weeks) N = 7
carrots	3.59	3.44	3.24
peas	3.52	3.52	4.0
beans	3.35	3.29	3.0
corn	3.35	3.76	4.14

* Category Response:

1 = obviously dislikes

2 = seems to dislike

3 = indifferent

4 = seems to like

5 = obviously likes

Table 7.3

Comparison of Mean Preference Scores* For Each Vegetable (Regarding Form) By Age

Vegetable	AGE 1 (< 10 weeks) N = 9	AGE 2 (10 < 16 weeks) N = 22	AGE 3 (≥ 16 weeks) N - 7
ccrt	3.44	3.18	2.95
fcrt	3.74	3.70	3.52
cpea	3.37	3.61	3.81
fpea	3.67	3.42	4.19
cbns	3.59	3.39	3.05
fbns	3.11	3.18	2.95
ccrn	3.22	3.77	4.14
fcrn	3.48	3.74	4.14

* Category Response:

1 = obviously dislikes

2 = seems to dislike

3 = indifferent

4 = seems to like

5 = obviously likes

had the same lower preference scores for canned carrots as they did for frozen beans.

These preference scores merely provide an overall assessment of preference. Thus it appears that preference for either form of corn increases with age, while preference for canned carrots decreases with age. This change in preference for canned carrots, as infants become older, agrees with those reported by Maslansky (1974).

2. Test Hypotheses II

(a) Infants within the three age groups exhibit the same preference for all canned vegetables and for all frozen vegetables.

The above hypothesis was accepted. No significant differences in preference were found (Table 8.1).

(b) Between two age groups, infants exhibit the same preference for all canned vegetables and for all frozen vegetables.

No significant differences were found as seen in Table 8.2. The null hypothesis was accepted.

(c) Infants within the three age groups exhibit the same preference for each vegetable.

Table 8.3 shows no significance was found, thus the null hypothesis was accepted.

Table 8.1

Preference for All Canned and All Frozen

Vegetables by Age

Kruskall-Wallis Analysis of Variance

Cnd Pref	N	Mean Rank	Chi Square	Probability
AGE 1	9	17.50	0.443	n.s
AGE 2	22	20.41		
AGE 3	7	19.21		
Frz Pref				
AGE 1	9	19.00	0.174	n.s.
AGE 2	22	19.20		
AGE 3	7	21.07		

Table 8.2

Preference for All Canned and All Frozen Vegetables

Between Age Groups

Mann-Whitney U Test

	Age Group	N	Mean Rank	U	Probability
Cnd Pref	1	9	14.28	83.5	n.s.
	2	22	16.70		
	1	9	8.22	29.0	n.s.
	3	7	8.86		
	2	22	15.20	72.5	n.s.
	3	7	14.36		
Frz Pref	1	9	15.78	97.0	n.s.
	2	22	16.09		
	1	9	8.22	29.0	n.s.
	3	7	8.86		
	2	22	14.61	68.5	n.s.
	3	7	16.21		

Table 8.3

Preference for Each Vegetable by Age

Kruskall-Wallis Analysis of Variance

Vegetable	Age Group	N	Mean Rank	Chi Square*	Probability
ccrt	1	9	20.56	0.320	n.s.
	2	22	19.70		
	3	7	17.50		
cpea	1	9	19.06	0.029	n.s.
	2	22	19.52		
	3	7	20.00		
cbns	1	9	20.22	0.521	n.s
	2	22	20.07		
	3	7	16.79		
ccrn	1	9	15.28	2.630	n.s.
	2	22	19.75		
	3	7	24.14		
fcrt	1	9	20.72	0.226	n.s.
	2	22	19.43		
	3	7	18.14		
fpea	1	9	20.44	2.799	n.s.
	2	22	17.32		
	3	7	25.14		
fbns	1	9	19.00	0.113	n.s.
	2	22	20.00		
	3	7	18.57		
fcrn	1	9	17.39	1.238	n.s.
	2	22	19.16		
	3	7	23.29		

* Corrected for Ties

(d) Between two age groups, infants exhibit the same preference for each vegetable.

No significant differences were found and the null hypothesis was accepted (Table 8.4).

Two possible trends are indicated. Infants in AGE 3 tend to like canned corn more than those in AGE 1. The older infants also tend to like frozen peas more than those in AGE 2.

(e) Within one age group, infants exhibit the same preference for all canned vegetables as they do for all frozen vegetables.

The null hypothesis was accepted. No significant differences were found (Table 8.5).

(d) Within one age group, infants exhibit the same preference for each of the canned vegetables and for each of the frozen vegetables.

No significant differences were found and the null hypothesis was accepted (Table 8.6).

It is interesting to notice that canned corn had the highest mean rank for AGES 2 and 3, but the lowest mean rank for AGE 1. The mean rank for frozen corn in AGE 1 was the second lowest, while for AGE 2, it was the highest in the frozen group. In AGE 3 it was tied for highest mean rank with frozen peas. This may suggest that subjects less than ten weeks of age did not prefer corn to the same extent as did those infants ten weeks of age and over.

Among the canned vegetables, canned carrots had the lowest mean rank for AGE 2 and 3, but the highest rank for AGE 1. In all three

Table 8.4

Preference for Selected Vegetables Between Age Groups

Mann-Whitney U Test

Vegetable	Age Group	N	Mean Rank	U	Probability (Trend)
ccrn	1	9	6.89	17.0	n.s. (< 0.20)
	3	7	10.57		
fpea	2	22	13.52	44.5	n.s. (< 0.20)
	3	7	19.64		

Table 8.5

Canned vs Frozen Preference Within Each Age Group

Wilcoxon Matched-Pairs Signed-Rank Test

Age Group	N	Cnd Pref - Ranks	Frz Pref + Ranks	z	Probability
1	9	4	5	-0.355	n.s.
2	22	8	13	-0.400	n.s.
3	7	2	4	-0.943	n.s.

Table 8.6

Preference for Canned Vegetables and Frozen Vegetables

Within Each Age Group

Friedman Analysis of Variance

	Vegetable	Mean Rank	Chi Square	d f	Probability
AGE 1	ccrt	2.72	0.433	3	n.s.
N = 9	cpea	2.44			
	cbns	2.50			
	ccrn	2.33			
	fcrt	2.94	1.833	3	n.s.
	fpea	2.56			
	fbns	2.17			
	fcrn	2.33			
AGE 2	ccrt	2.27	1.418	3	n.s.
N = 22	cpea	2.55			
	cbns	2.45			
	ccrn	2.73			
	fcrt	2.66	2.864	3	n.s.
	fpea	2.52			
	fbns	2.11			
	fcrn	2.70			
AGE 3	ccrt	2.00	2.957	3	n.s.
N = 7	cpea	2.71			
	cbns	2.21			
	ccrn	3.07			
	fcrt	2.50	2.057	3	n.s.
	fpea	2.79			
	fbns	1.93			
	fcrn	2.79			

age groups, frozen beans had the lowest mean rank. While none of these findings is significant, an examination of the mean rank does provide some information as to which direction preferences may lay.

(g) Within one age group, infants exhibit the same preference for one vegetable as they do for another (i.e. using all combinations of vegetable and form).

No significant differences in preference were found and the null hypothesis was accepted (Table 8.7).

Trends in vegetable preference appear to increase with age. For AGE 1, three possible preferences are suggested. For AGE 2, four preferences are suggested. The number of suggested preferences increased to eight for the oldest group of infants. Thus it appears that as an infant becomes older, he may become more discriminating and is more definite about the vegetables he likes and dislikes.

Table 8.8 describes the vegetable preference as suggested by the trends arising from Table 8.7. Considering the data for all age groups, canned carrots appeared less preferred six times, frozen beans less preferred five times, canned beans three times, and canned corn once. The vegetables that seem most preferred were canned corn or frozen corn appearing six times; frozen peas and frozen carrots, three times; canned peas, two times; and canned beans on one occasion. These trends correspond with the significant results found in Hypothesis I (d), and the trends found there. That is, that frozen beans and canned carrots were less preferred

Table 8.7

Preference for Selected Vegetable Pairs by Age Groups

Wilcoxon Matched-Pairs Signed-Rank Test

	Vegetable	-Ranks	+Ranks	z	Probability (< 0.20)
AGE 1	fcrt - ccrt	2	7	-1.599	n.s.
N = 9	cbns - fbns	2	4	-1.468	n.s.
	fcrt - ccrn	1	6	-1.362	n.s.
AGE 2	ccrn - ccrt	5	11	-1.603	n.s.
N = 22	fcrt - ccrt	4	10	-1.287	n.s.
	fcrn - ccrt	6	11	-1.396	n.s.
	ccrn - fbns	4	13	-1.633	n.s.
AGE 3	cpea - ccrt	1	4	-1.753	n.s.
N = 7	fpea - ccrt	2	5	-1.521	n.s.
	cpea - fbns	2	4	-1.363	n.s.
	fpea - fbns	1	4	-1.753	n.s.
	fcrn - fbns	2	4	-1.363	n.s.
	ccrn - cbns	2	4	-1.572	n.s.
	fpea - cbns	2	5	-1.521	n.s.
	fcrn - cbns	1	5	-1.572	n.s.

Table 8.8

Suggested Vegetable Preference by Age Groups

	Pref > ccrt	Pref > fbns	Pref > cbns	Pref > ccrn
AGE 1	fcrt	cbns		fcrt
AGE 2	fcrt	ccrn		
	fcrn			
	ccrn			
AGE 3	cpea	cpea	ccrn	
	fpea	fpea	fpea	
		fcrn	fcrn	

and frozen carrots, canned corn and frozen corn more preferred. In only one instance was the preferred vegetable pair the same for two age groups. Infants in AGE 1 and 2 both seem to prefer frozen carrots over canned carrots. Preference for frozen carrots is not evident for AGE 3. The suggested trends in preference from one age group to another does not seem to follow any set pattern, suggesting perhaps that infant vegetable preferences change with age. It has been reported that infants have willingly accepted a food initially only to refuse it later (Beal, 1957; Guthrie, 1966; Maslansky et al, 1974). While canned corn appears less preferred by AGE 1, it appears as the preferred vegetable three times in AGES 2 and 3. Similarly canned beans may be preferred by AGE 2 over frozen beans, but AGE 3 indicates three possible preferences over canned beans. A possible preference for canned and frozen peas does not arise until infants are sixteen weeks and over.

3. Summary Discussion

Age did not have a significant effect on the vegetable preferences of infants in this study. All test hypotheses were accepted. However, the trends as discussed in the last section, indicate that as infants get older, they become more discriminating and exhibit more vegetable preferences. In addition, suggested preferences of younger infants appear unrelated to preferences exhibited by older infants.

D. Effect of Previous Feeding Regime on Vegetable Preference

Subjects were divided into two groups. Thirteen infants who had had no previous exposure to fruit constituted the VEG 1 group. The VEG 2 group consisted of twenty-five infants who had tasted fruit prior to the consumption of vegetables. The age distribution was relatively balanced with no one age group dominating either of these groups.

1. Overall Assessment

In comparing the mean preference scores for canned vegetables between these two groups, there appears to be no difference in preference for the canned group (Table 9.1). However, VEG 1 infants appear to prefer frozen vegetables more than do the VEG 2 infants.

From Table 9.2, it can be seen that VEG 1 infants prefer corn followed by beans. VEG 2 infants prefer peas, then corn, while beans received the lowest score. In all cases, except peas, the mean preference scores for VEG 1 subjects are greater than VEG 2. This suggests that vegetables might be more preferred by those infants who have not been exposed to fruit first.

Table 9.3 also suggests that infants fed vegetables first prefer vegetables more than those fed fruit first. VEG 1 infants had greater preference scores for six out of eight vegetables. The highest score by VEG 1 was 4.51 for frozen corn and 4.08 for frozen carrots. The

Table 9.1

Comparison of Mean Preference Scores for Canned vs Frozen Vegetables by VEG 1 and VEG 2

Form of Vegetable	VEG 1 N = 13	VEG 2 N = 25
Cnd Pref	3.49	3.47
Frz Pref	3.94	3.39

Table 9.2

Comparison of Mean Preference Scores for Each Vegetable (Disregarding Form) by VEG 1 and VEG 2

Vegetable	VEG 1 N = 13	VEG 2 N = 25
Carrots	3.54	3.43
Peas	3.57	3.62
Beans	3.63	3.06
Corn	4.19	3.56

Table 9.3

Comparison of Mean Preference Scores for Each Vegetable (Regarding Form) By VEG 1 and VEG 2

Vegetable	VEG 1 N = 13	VEG 2 N - 25
ccrt	3.00	3.32
fcrt	4.08	3.53
cpea	3.26	3.71
fpea	3.87	3.52
cbns	3.69	3.23
fbns	3.56	2.89
ccrn	3.87	3.63
fcrn	4.51	3.48

highest score for VEG 2 infants was 3.71 for canned peas and 3.63 for canned corn. Frozen beans were the least preferred vegetable by VEG 2 infants (2.89) while they received a mean score of 3.56 by VEG 1 infants. Canned carrots and canned peas had the lowest preference scores for VEG 1.

Therefore, it appears that VEG 1 infants prefer vegetables more than do VEG 2 infants. In addition, these two groups do not appear to like or dislike the same vegetables. The VEG 1 preference scores are higher than VEG 2 scores for all vegetables except canned carrots and canned peas.

2. Test Hypotheses III

(a) Infants within VEG 1 and VEG 2 exhibit the same preference for all canned vegetables and for all frozen vegetables.

No significant difference was found for canned preference between the two groups; therefore the hypothesis was accepted (Table 10.1). Infants in the VEG 1 group significantly preferred the frozen vegetables more than those infants in VEG 2 did.

(b) Infants within VEG 1 and VEG 2 exhibit the same preference for each vegetable.

No significant differences were found and the hypothesis was accepted (Table 10.2).

Two interesting trends are evident. Frozen beans and frozen corn may be more preferred by VEG 1 infants.

Table 10.1

Preference for All Canned and All Frozen Vegetables

By VEG 1 and VEG 2

Mann-Whitney U Test

	N	Rank	U	Probability
Cnd Pref				
VEG 1	13	19.62	161.0	n.s.
2	25	19.44		
Frz Pref				
VEG 1	13	24.65	95.5	0.039
2	25	16.82		

Table 10.2

Preference for Each Vegetable By VEG 1 and VEG 2

Mann-Whitney U Test

Vegetable		N	Mean Rank	U	Probability
ccrt	VEG 1	13	18.19	145.5	n.s.
	2	25	20.18		
cpea	VEG 1	13	16.85	128.0	n.s.
	2	25	20.88		
cbns	VEG 1	13	22.04	129.5	n.s.
	2	25	18.18		
ccrn	VEG 1	13	21.00	143.0	n.s.
	2	25	18.72		
fcrt	VEG 1	13	22.58	122.5	n.s.
	2	25	17.90		
fpea	VEG 1	13	19.08	157.0	n.s.
	2	25	19.72		
fbns	VEG 1	13	23.08	116.0	n.s. (< 0.20)
	2	25	17.64		
fcrn	VEG 1	13	24.15	102.0	n.s. (< 0.20)
	2	25	17.08		

(c) Infants in VEG 1 and VEG 2 exhibit the same preference for each canned vegetable and for each frozen vegetable.

From Table 10.3 it can be seen that no significant differences were found and the hypothesis was accepted.

Frozen beans had the lowest mean rank in the VEG 2 group. This suggests a lower preference for frozen beans by VEG 2 infants compared to other frozen vegetables. The highest mean ranks for the VEG 1 group were for canned corn and frozen corn, while those for VEG 2 were canned peas and frozen peas. The lowest mean ranks for the VEG 1 group were canned peas and frozen beans, and canned beans and frozen beans for VEG 2. The preference of infants for corn which has appeared in the previous analysis is not evident in the VEG 2 group. Of the canned vegetables, canned peas had the highest rank for VEG 2 group, while they had the lowest rank for VEG 1.

(d) Infants within VEG 1 and within VEG 2 exhibit the same preference for both canned and frozen vegetables.

The hypothesis was rejected for VEG 1 (Table 10.4). Infants in VEG 1 prefer frozen vegetables over canned vegetables. The hypothesis was accepted for VEG 2, as no significant differences in preference were found.

Table 10.3

Preference for Each Canned Vegetable and Each Frozen Vegetable Within VEG 1 and VEG 2

Friedman Analysis of Variance

	Vegetable	Mean Rank	Chi Square	d f	Probability
VEG 1					
N = 13	ccrt	2.27	3.069	3	n.s.
	cpea	2.12			
	cbns	2.77			
	ccrn	2.85			
	fcrt	2.65	2.885	3	n.s.
	fpea	2.23			
	fbns	2.19			
	fcrn	2.92			
VEG 2					
N = 25	ccrt	2.36	2.700	3	n.s.
	cpea	2.78			
	cbns	2.24			
	ccrn	2.62			
	fcrt	2.72	4.920	3	n.s. (< 0.20)
	fpea	2.76			
	fbns	2.04			
	fcrn	2.48			

Table 10.4

Preference for Canned vs Frozen Vegetables

by VEG 1 and VEG 2

Wilcoxon Matched-Pairs Signed-Rank Test

	N	Cnd Pref − Ranks	Frz Pref + Ranks	z	Probability
VEG 1	13	3	10	2.341	0.019
VEG 2	25	11	12	-0.487	n.s.

(e) Infants within VEG 1 and within VEG 2 exhibit the same preference for one vegetable as they do for another (i.e. using all combinations of vegetables and form).

The hypothesis was rejected four times for VEG 1 and three times for VEG 2 (Table 10.5). The total number of individual comparison was twenty-eight. Infants in VEG 1 significantly preferred frozen carrots and frozen corn over canned carrots, and canned corn and frozen corn over canned peas. The significant preferences for the VEG 2 group are unrelated to those in VEG 1. Canned peas, canned corn and frozen carrots were preferred over frozen beans.

Table 10.5 also illustrates trends in preference for selected vegetable pairs. For the VEG 1 group, seven possible trends in preference are indicated, while three trends exist for VEG 2.

The suggested and significant vegetable trends are outlined in Table 10.6. Those vegetables least preferred by VEG 1 infants most often, or suggested to be so, were canned carrots and canned peas. Only canned beans and frozen beans were less preferred, or appeared to be so, by the VEG 2 group. The only canned vegetable which seemed to be preferred by the VEG 1 infants was canned corn. Frozen corn is seen as being more preferred on four occasions by this group.

Four vegetables are suggested to be more preferred than both canned carrots and canned peas by the VEG 1 group. Of these, three are frozen preferences. A preference or inclination towards such

Table 10.5

Preference for Selected Vegetable Pairs

by VEG 1 and VEG 2

Wilcoxon Matched-Pairs Signed-Rank Test

	Vegetable	-Ranks	+Ranks	z	Probability Significant (≤0.05)	Probability Trends (<0.20)
VEG 1						
N = 13	ccrn = ccrt	3	7	-1.682		n.s.
	fcrt - ccrt	0	7	-2.366	0.018	
	fpea - ccrt	4	6	-1.529		n.s.
	fcrn - ccrt	2	8	-2.039	0.041	
	ccrn - cpea	3	8	-1.956	0.050	
	fcrt - cpea	2	10	-1.804		n.s.
	fpea - cpea	4	8	-1.490		n.s.
	fcrn - cpea	1	10	-2.623	0.009	
	fcrn - cbns	3	7	-1.376		n.s.
	fcrn - fbns	2	7	-1.896		n.s.
VEG 2						
N - 25	cpea - cbns	7	16	-1.430		n.s.
	cpea - fbns	5	16	-2.155	0.031	
	cbns - fbns	7	13	-1.400		n.s.
	ccrn - fbns	6	17	-1.992	0.046	
	fcrt - fbns	6	16	-2.094	0.036	
	fpea - fbns	5	14	-1.751		n.s.

Table 10.6

Significant and Suggested Vegetable Preferences

By VEG 1 and VEG 2

	Pref > ccrt	Pref > cpea	Pref > cbns	Pref > fbns
VEG 1	ccrn	ccrn*	fcrn	fcrn
	fcrt*	fcrt		
	fpea	fpea		
	fcrn*	fcrn*		
VEG 2			cpea	cpea*
				cbns
				ccrn*
				fcrt*
				fpea

* Significant at $P \leq 0.05$

preference is not seen in VEG 2. VEG 2 infants appear inclined to dislike frozen beans, while this dislike is not evident for VEG 1. With the exception of frozen carrots, VEG 2 infants seem to prefer the canned vegetables. Interesting also, is that frozen corn appears as more preferred by VEG 1 four times, while it does not appear at all for VEG 2.

3. Summary Discussion

Infants within VEG 1 and VEG 2 exhibit the same preference for canned vegetables. Frozen vegetables were significantly preferred by VEG 1 infants when compared to VEG 2 infants. Significant preferences between vegetable pairs were found for both groups, but the patterns of preference are not similar. Canned carrots and canned peas were less preferred by VEG 1 while frozen beans were less preferred by VEG 2. Frozen corn was more preferred by VEG 1 but not by VEG 2 infants. In general, infants in VEG 1 prefer the frozen vegetables, while those in VEG 2 prefer canned. The overall mean preference scores suggest that infants fed vegetables before fruit tend to like vegetables better than those fed fruit first.

IV SENSORY ANALYSIS OF PURÉED VEGETABLES

A. Statistical Analysis

A trained adult panel assessed the vegetables according to a variety of sensory parameters. Panelists used the technique of magnitude estimation (page 33). Two replications of each test were conducted. The reference samples were assigned a score of twenty. All scores were normalized by dividing each score by the geometric mean for each panelist. A value of 0.1 was used for any panelist who scored a characteristic as being "not present" (np). This score had to be given some number because of the manner in which magnitude estimation works. It must be small enough to give the impression that the parameter was not there, but not so small as to distort the normalization process. Data were analyzed at the one percent level of significance using a factorial analysis of variance with two replications in each cell. This level was selected because the researcher was primarily interested in extreme differences between samples. The Duncan's Multiple Range Test was conducted to determine where the significances lay.

Discussion of Interaction

The results and a discussion of these tests are outlined in the following pages. It must be mentioned here, however, that in almost all cases, a significant interaction between panelists and vegetables was found. This interaction suggests that not all panelists were scoring the same on both replications and/or that panelists' scores varied among themselves, but not enough to cause a significant panelist effect.

The raw data were examined to see where this interaction occurred. It appears that in those tests where one or more of the panelists used a score of "np", the F value for interaction was greater. When an analysis of variance was conducted on some of the data omitting those panelists who used "np", the F value for interaction was still significant, but much smaller.

Those panelists who used a score of "np" have much smaller geometric means than those who did not. This tends to inflate the normalized scores. For example, Panelist One had two np's for bitterness in frozen beans and frozen corn and a geometric mean of 1.396. Panelist Three used no np's and had a geometric mean of 3.826. Panelist One gave frozen carrots a score of five for bitterness, while Panelist Three gave them a score of seven. The normalized data were 2.952 and 1.016 respectively. The score for Panelist One was almost three times as great as that for Panelist Three. Thus some interaction is present.

As long as a panelist used np's for the same vegetable on both replications, the normalized scores are similar. If a panelist used "np" on one replicate but assigned a score to the other, the normalized scores vary. For example, in estimating the sweetness of frozen carrots, the third panelist gave a score of seven on one test and "np" on the next. The resulting normalized scores are 1.371 and 0.02 respectively. This large difference between replications may likely result in interaction. When these two scores are averaged, they are compatible with the other panelists'

scores, thus causing no panelist effect.

In some of the sensory tests, there exists a discrepancy between panelists' scores. That is, they did not always agree with each other's scores. None of these discrepancies are so great that they cause a significant panelist effect, yet they may be responsible for some of the interaction. In examining the raw scores, panelists appear to agree on the order of their estimates. While the actual value of the scores may be different, the order in which the scores lie are in agreement. Through the process of normalization, differences sometimes develop and thus may result in interaction.

The presence of a significant interaction should not be ignored, as it acts as evidence to show that panelists did not perform as well as expected. In addition, this interaction suggests that the use of "np" as a judgment should be investigated to determine how substituting different values for "np" may affect the results of similar magnitude estimation tests.

Even though the presence of significant interaction casts a shadow of doubt on the integrity of the data, the researcher was confident that definite differences within the samples did exist. Due to this confidence, coupled with a highly significant F value for vegetables, the Duncan's Multiple Range Test was conducted to determine where the differences occurred.

B. Estimates of Taste Intensities of Puréed Vegetables Expressed as Concentrations of Sucrose, Citric Acid and Caffeine Solutions

Linear regression analyses were conducted on data resulting from the trained panel magnitude estimates of varying concentrations of solutions of three of the basic tastes, sweet, sour and bitter (Appendix N). The slope of the resulting line or power function, was 1.534 for sucrose, 1.118 for citric acid and 1.257 for caffeine.

A trained panel estimate of the sweetness perceived in each of the vegetables expressed as a concentration of sucrose in tap-distilled water, can be seen in Table 11.1. These sweetness estimates were determined by the use of the sweetness power function. The power function is known to be a constant and can therefore, be used to compare sweetness estimates from separate taste sessions. Because all vegetable samples were compared to a reference two percent sucrose solution on a ratio basis, and because the power function is known, the strength of sucrose solution necessary to replicate the vegetable sweetness can be determined.

The method used to determine these concentrations is described by first finding the ratio between the amount of sweetness perceived in each vegetable compared to that perceived in the reference solution (two percent sucrose). This ratio (R) was determined by dividing the average vegetable score by the average reference score. The magnitude estimate for the reference solution (Y) was calculated

using the formula for a straight line $Y = a + bX$. To obtain the magnitude estimate (Y') for each vegetable, (R) (Y) was calculated. The percent sucrose solution (X) for each Y' value was determined by solving for X when $X = \frac{Y' - a}{f}$. Thus the value of X represents the percent concentration of sugar equal to the sweetness of each vegetable. The same procedure was followed to determine the sourness and bitterness of each vegetable expressed in terms of percent solutions of citric acid and caffeine.

The following calculations illustrate how the sweetness of frozen peas was determined as a concentration of sucrose solution.

Mean panelist score for sweetness of frozen peas = 4.06

Mean panelist score for sweetness of reference (two percent sucrose) = 2.685

$$\text{Ratio} = \frac{\overline{X} \text{ Vegetable Score}}{\overline{X} \text{ Reference Score}} = 1.512$$

Magnitude estimate (Y) for reference:

$$Y = a + bX$$

$$Y = 1.3$$

Magnitude estimate (Y') for frozen peas:

$$Y' = (R)\ (Y)$$

$$Y' = 1.966$$

Percent sucrose solution (X) for frozen peas magnitude estimate (Y'):

$$X = \frac{Y' - a}{b}$$

$$X = 2.612$$

From Table 11.1, it can be seen that frozen peas and canned carrots were both comparable to slightly more than a two percent sucrose solution. The least sweet vegetable, frozen carrots and canned beans are about equal to a 0.5% sucrose solution.

Only three vegetables were found to contain a sour taste (Table 11.2). Canned carrots were found to be comparable to a 0.09% citric acid solution. Canned peas and canned beans were about equal to a 0.05% concentration of citric acid.

The most bitter vegetables were canned peas and canned carrots, comparable to approximately 0.05% caffeine (Table 11.3). The least bitter were frozen beans and frozen corn equal to a 0.01% caffeine solution. Frozen peas and canned corn were found to contain no bitterness.

No infant recognition thresholds have been documented in the literature. Adult recognition thresholds range from 0.411% to 1.267% sucrose, 0.00858% to 0.0376% for citric acid and 0.0058% to 0.0144% for caffeine (Amerine et al, 1965). The equivalent concentration of each of the stimuli as perceived in the vegetable samples are above adult thresholds.

Table 11.1

Trained Panel Estimation of the Sweetness Perceived in Puréed Vegetables Expressed as a Concentration of Sucrose in Water

Vegetable	Percent Sucrose (Weight by Volume in tap-distilled water)
fpea	2.6
ccrt	2.3
ccrn	1.8
cpea	1.2
fbns	1.1
fcrn	0.9
fcrt	0.6
cbns	0.5

Reference = Two Percent sucrose weight by volume in tap-distilled water

Table 11.2

Trained Panel Estimation of the Sourness Perceived in Puréed Vegetables Expressed as a Concentration of Citric Acid in Water

Vegetable	Percent Citric Acid (Weight by Volume in tap-distilled water)
ccrt	0.09
cpea	0.05
cbns	0.04

Reference = 0.1% citric acid weight by volume in tap-distilled water

Table 11.3

Trained Panel Estimation of the Bitterness Perceived in Puréed Vegetables Expressed as a Concentration of Caffeine in Water

Vegetable	Percent Caffeine (Weight by Volume in tap-distilled water)
cpea	0.05
ccrt	0.04
cbns	0.02
fcrt	0.02
fbns	0.01
fcrn	0.01

Reference = 0.09% caffeine weight by volume in tap-distilled water

C. Taste Parameters

Vegetables were scaled by the trained panel according to the degree of sweet, sour and bitter tastes perceived. The findings are discussed below. The Analysis of Variance tables are found in Appendix Q. A histogram representing each of the parameters illustrates the mean magnitude estimates and the results of Duncan's Multiple Range Test.

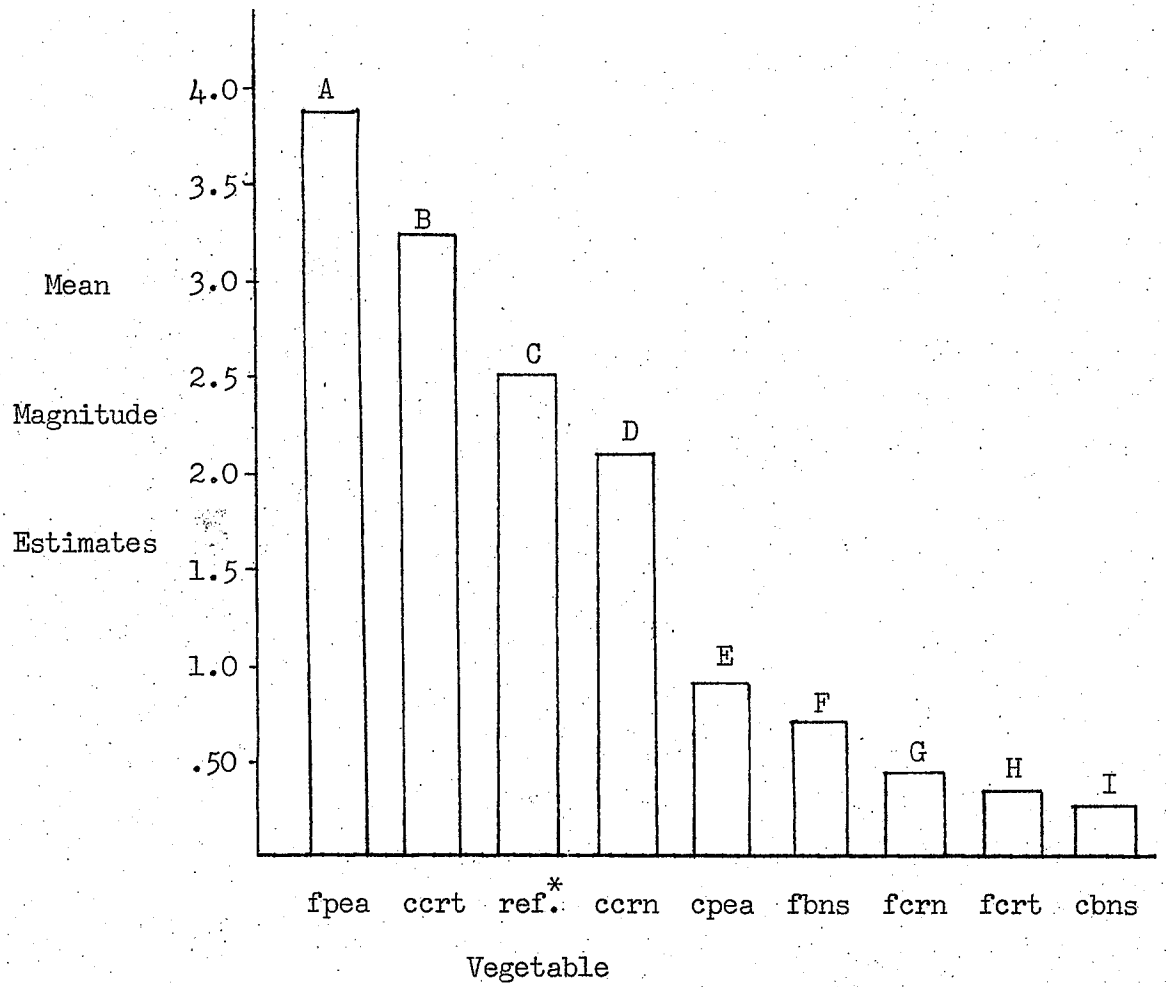
1. Sweetness

Vegetables were found to be significantly different in the amount of sweetness perceived (Appendix Q_1). Frozen peas, canned carrots and canned corn were found to be as sweet as that perceived in a two percent solution of sucrose and greater in sweetness than all other vegetables (Figure 5). Frozen corn, frozen carrots and canned beans were judged to be the least sweet, being about one-tenth as sweet as the reference sample. Canned peas and frozen beans were about one-third as sweet as the reference and significantly sweeter than frozen carrots and canned beans.

Frozen peas received the highest score for sweetness followed by canned carrots. Panelists commented that while the initial sweetness of canned carrots was quite strong, it quickly dissipated and was followed by sensations of sour and bitter.

It is interesting to note that canned vegetables are higher in sweetness than frozen vegetables, excluding canned beans and

MAGNITUDE ESTIMATES OF SWEETNESS IN PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D E F G H I

* Reference = 2% sucrose weight by volume in tap-distilled water

Figure 5

frozen peas. Manufacturers add sugar to all but canned peas and beans. The frozen products contained only their natural sugar. As both the frozen peas and canned peas have no added sugar, peas seem to contain a fair amount of natural sweetness. The majority of the frozen vegetables are found at the lower end of the sweetness scale.

Panelists assessed the degree of pleasantness for the reference solution on a nine point category scale (Appendix J). The mean score over four replications was 6.29, indicating the reference was slightly pleasant. The mean score would have been higher except two of the panelists who do not like sweetness, rated the reference as slightly unpleasant to unpleasant. All other panelists agreed the reference was pleasant or very pleasant. Thus those vegetables with an equal sweetness to the reference appear to have a relatively pleasant sweet taste.

Relationship Between Sweetness and Infant Vegetable Preference

An innate preference for sweetness by infants has been documented by many researchers (Dubignon et al, 1969; Aiyar et al, 1969; Nisbett et al, 1970; Desor, 1973; Steiner, 1974; Nowlis et al, 1976). Hence, one may suspect that those vegetables possessing a high degree of sweetness would be most preferred, that is, frozen peas, canned carrots and canned corn. Only canned corn was found to be significantly preferred over frozen beans by all subjects and a trend in preference was seen for canned corn over canned carrots.

A trend towards increased preference for frozen peas over canned carrots and frozen beans is also evident. This finding is interesting in that canned carrots, in spite of their high degree of sweetness, were among the less preferred vegetables. Frozen carrots and frozen corn were also found to be significantly preferred over frozen beans and possibly over canned carrots. Their level of sweetness was low, being approximately one-tenth as sweet as the reference.

Older infants may be more partial to sweeter vegetables than younger infants. Infants less than ten weeks of age (AGE 1) exhibit only three trends in vegetable preference. Of these, none of the so-called sweet vegetables is preferred. In fact, the frozen carrots appeared to be more preferred than canned corn, which is significantly sweeter. For infants, ten weeks less than sixteen weeks, (AGE 2), canned corn appears as possibly more preferred along with the less sweet frozen carrots and frozen corn. The oldest group of infants has the most trends in preference. An increased preference for the sweeter vegetables is evident here - frozen peas, canned corn, and although less sweet, canned peas. Among the least sweet vegetable, frozen corn was still preferred, but frozen carrots were not.

In all age groups, frozen beans and canned carrots seemed to be less preferred. These vegetables are significantly different in sweetness. Canned carrots are high in sweetness. If sweetness were the only factor involved in infant vegetable preference, one would

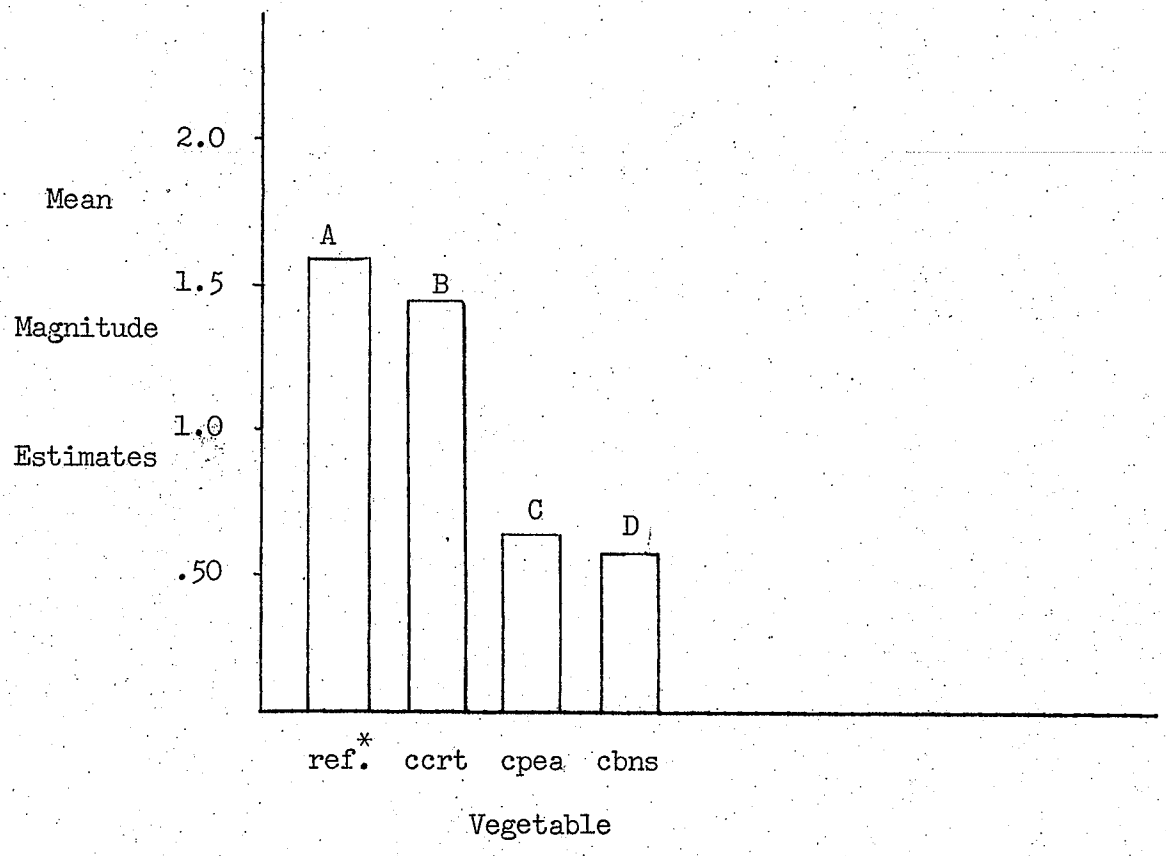
expect to see them as one of the most preferred vegetables, and frozen beans less preferred because of their lower sweetness. Both vegetables are consistently found to be significantly or suggested to be less preferred. Obviously factors other than sweetness are involved.

Infants fed vegetables before fruit (VEG 1) and those fed fruit first (VEG 2) both exhibit preferences for vegetables with varying degrees of sweetness. Of interest in this group is that VEG 1 infants preferred canned carrots and canned peas less, and these were found to be relatively sweet vegetables. For VEG 2 infants, canned carrots do not appear as less preferred. Canned peas however, appear as more preferred on two occasions by this group. Thus it is possible that VEG 2 infants are more partial to the sweetness of these two vegetables than are VEG 1 infants. Furthermore, more of the canned vegetables are preferred by this group than are the less sweet frozen vegetables. Thus it may be that infants fed fruits are more partial to sweet vegetables. Perhaps this is due to their familiarity with the sweet taste of fruit.

2. Sourness

Of all the vegetable samples, three canned vegetables were found to contain a sour taste. Significant differences in the degree of sourness was found (Appendix Q_{ii}). The magnitude of these differences is found in Figure 6. Panelists found canned

MAGNITUDE ESTIMATES OF SOURNESS IN PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D

* Reference = 0.1% citric acid weight by volume in tap-distilled water

Figure 6

carrots to be the most sour, comparable to that perceived by a 0.1% citric acid solution. Canned peas and canned beans were judged to be about half as sour as the reference. None of the frozen vegetables were found to be sour.

The mean score for pleasantness of the reference solution was 3.76, indicating the reference was slightly unpleasant. This score would have been lower except for two panelists who enjoy sourness and found the reference pleasant. The remaining panelists found the reference unpleasant. Thus it appears that the amount of sourness found in canned carrots may be termed unpleasant for the majority of panelists.

Relationship Between Sourness and Infant Vegetable Preference

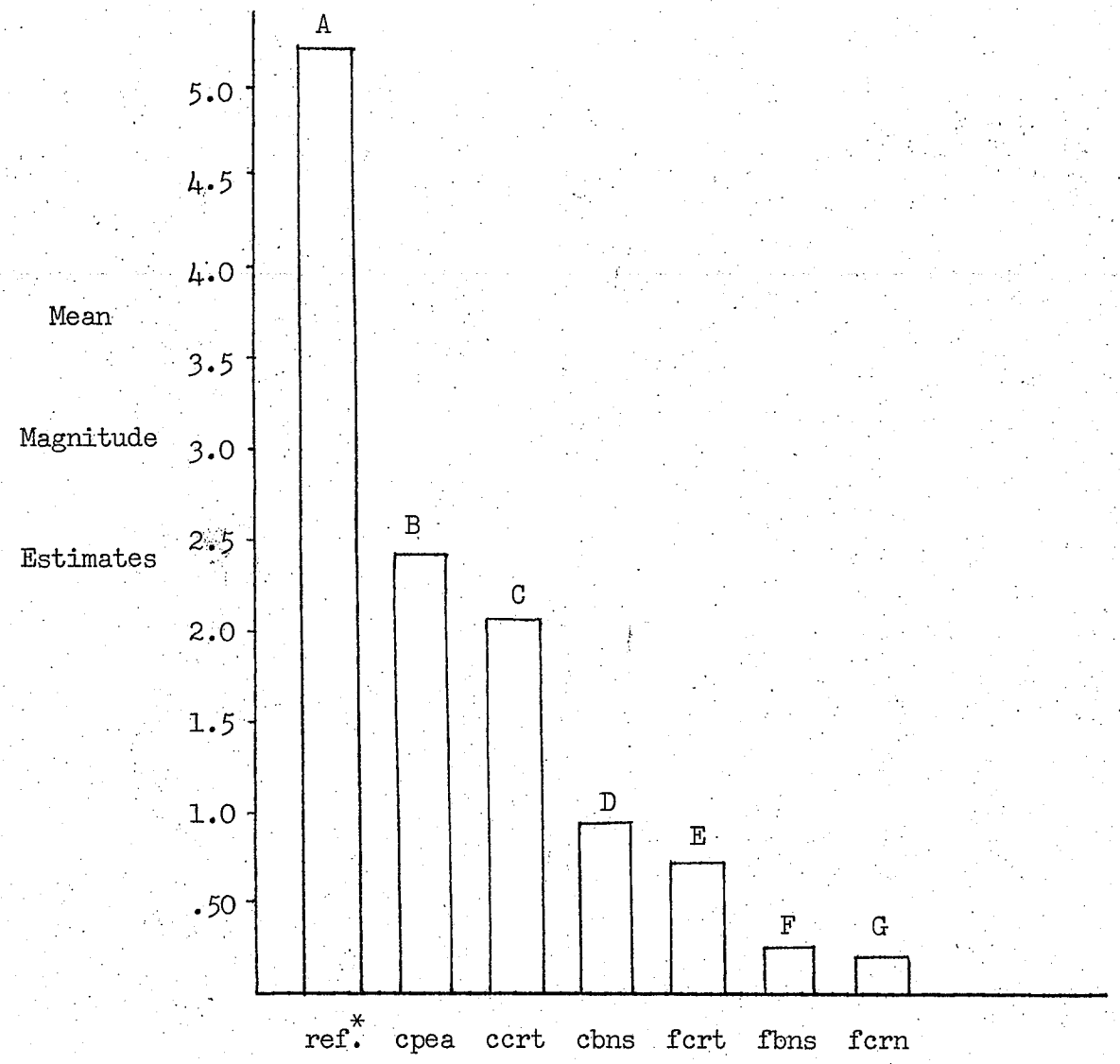
One may suspect that those vegetables which produce a sensation of sourness may be less preferred than those which do not. Previous research has demonstrated that infants are capable of tasting sour stimuli (Kussmaul, 1895; Preyer, 1895; Pratt et al, 1930; Kulakowskaja, 1930; Osepian, 1958; Aiyar et al, 1969). Steiner (1974) has shown that infants exhibit negative facial expressions in response to strong solutions of citric acid. Desor et al (1975) found that infants reacted to sour solutions by decreasing the volume of solution consumed. It appears then that infants can taste sourness and do not like it. In almost every statistical analysis of vegetable preference, canned carrots were suggested to be or were significantly less preferred. Thus it is possible that the high degree of sourness

in canned carrots was responsible for their lower preference. A lower preference for the slightly sour canned peas or canned beans was not evident. However, a preference for these vegetables was also not evident. None of the most frequently preferred vegetables contained a sour taste. This suggests that sourness may adversely affect infant vegetable preference.

3. Bitterness

A significant difference in bitterness was found (Appendix Q_{iii}). Figure 7 illustrates the mean magnitude estimate of those vegetables analyzed for bitterness, together with the results of the Duncan's Multiple Range Test. A 0.09% caffeine solution represented the reference sample. No vegetable was equal in bitterness to the reference. Both canned peas and canned carrots were assessed to be about one-half as strong as the reference sample. Frozen carrots and canned beans were about one-quarter as strong as the reference, and frozen beans and frozen corn, about one-tenth. It can be seen that frozen vegetables occupy the lower end of the bitterness scale while canned vegetables are found at the higher end. Canned corn and frozen peas did not produce any bitter sensations and were omitted from this analysis. The mean score for degree of pleasantness of the reference solution was 3.27, indicating the reference was unpleasant.

MAGNITUDE ESTIMATES OF BITTERNESS IN PUREED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D E F G

* Reference = 0.09% caffeine weight by volume in tap-distilled water

Figure 7

Relationship Between Bitterness and Infant Vegetable Preference

Infant reaction to bitter stimuli is controversial. Previous research has shown that infants react negatively to bitter solutions (Kussmaul, 1895; Preyer, 1895; Eckstein, 1927; Stirniman, 1930; Kulakowskaja, 1930; Aiyar et al, 1969; Steiner, 1974). However, Desor et al (1975) and Maller et al (1974) concluded from their findings that infants are unable to taste bitterness. The concentrations of urea used were estimated to be neutral to unpleasant by adults. Therefore, it is difficult to determine if the degree of bitterness perceived in a vegetable may adversely affect infant vegetable preference.

Canned peas had the highest degree of bitterness. A decreased preference for them is not evident for all infants. Canned carrots have a comparable amount of bitterness to canned peas, yet they were frequently suggested to be less preferred. The amount of bitterness found in frozen beans is so slight that it is doubtful that infant dislike of frozen beans was caused by this factor. The bitterness in frozen carrots did not appear to adversely influence infants, as frozen carrots were one of the vegetables preferred most often. However, infants in the oldest age group did not prefer frozen carrots. Osepian (1958) found increasing sensitivity to taste stimuli with age up to one year. However, he did not study bitterness stimuli. It is possible, therefore, that infants in the oldest age group are more sensitive to bitter tastes than are the younger infants. With the exception of canned carrots,

vegetables possessing bitter qualities do not appear to be less preferred by all subjects, suggesting that infants cannot detect bitterness, or if they can, they do not dislike it. It is impossible to determine if the decreased preference for canned carrots is due to the high degree of bitterness or sourness in this vegetable.

4. Summary of Taste Parameters and Infant Vegetable Preference

It is difficult to conclude from the findings of this study that infants base their food preferences on taste alone, or in fact, that they can actually taste. Vegetables containing both high and low levels of sweetness were preferred. Those vegetables with pronounced sour and bitter qualities were not always disliked. Only canned carrots were found to contain high degrees of all three taste qualities and also found to be consistently suggested to be or significantly less preferred.

While frozen beans were repeatedly less preferred than many other vegetables, their taste qualities have so far met with little discussion. The sweetness level was half that of the reference and almost twice as sweet as two of the more preferred vegetables, namely, frozen corn and frozen carrots. They did not contain any sourness and only a low level of bitterness. Thus there are no striking observations on taste quality which would indicate why they are less preferred. If taste quality were the only factor involved in infant vegetable preference, then a dislike for frozen

beans would not be expected.

In general, canned vegetables appear to possess more intense taste qualities than do the frozen vegetables. The majority of canned vegetables are sweeter, more sour and more bitter than the frozen vegetables. However, no significant differences in preference were found for canned versus frozen preference by all subjects. Infants fed vegetables first exhibit a significant preference for frozen over canned vegetables. This may be due to their unfamiliarity with sweet fruits and a greater acceptance of the less sweet frozen vegetables.

D. Texture Parameters

It appears that taste alone is not the only factor involved in infant vegetable preference. The feeling of a food within an infant's mouth may also be of importance. Therefore, all vegetables were assessed on a variety of textural parameters. Not all vegetables were analyzed for all texture parameters, as in some cases, the characteristic of interest was not present. The reference sample in each test was that vegetable which represented a good example of the characteristic of interest.

1. Dryness

A significant difference in the amount of dryness in the vegetable was found (Appendix R_i). The dryness for canned peas (reference sample) was not different than that detected for frozen carrots or frozen peas, but was significantly dryer than all other vegetables (Figure 8). Canned corn was the only vegetable that was significantly less dry than all other vegetables. The majority of frozen vegetables appears dryer than canned vegetables.

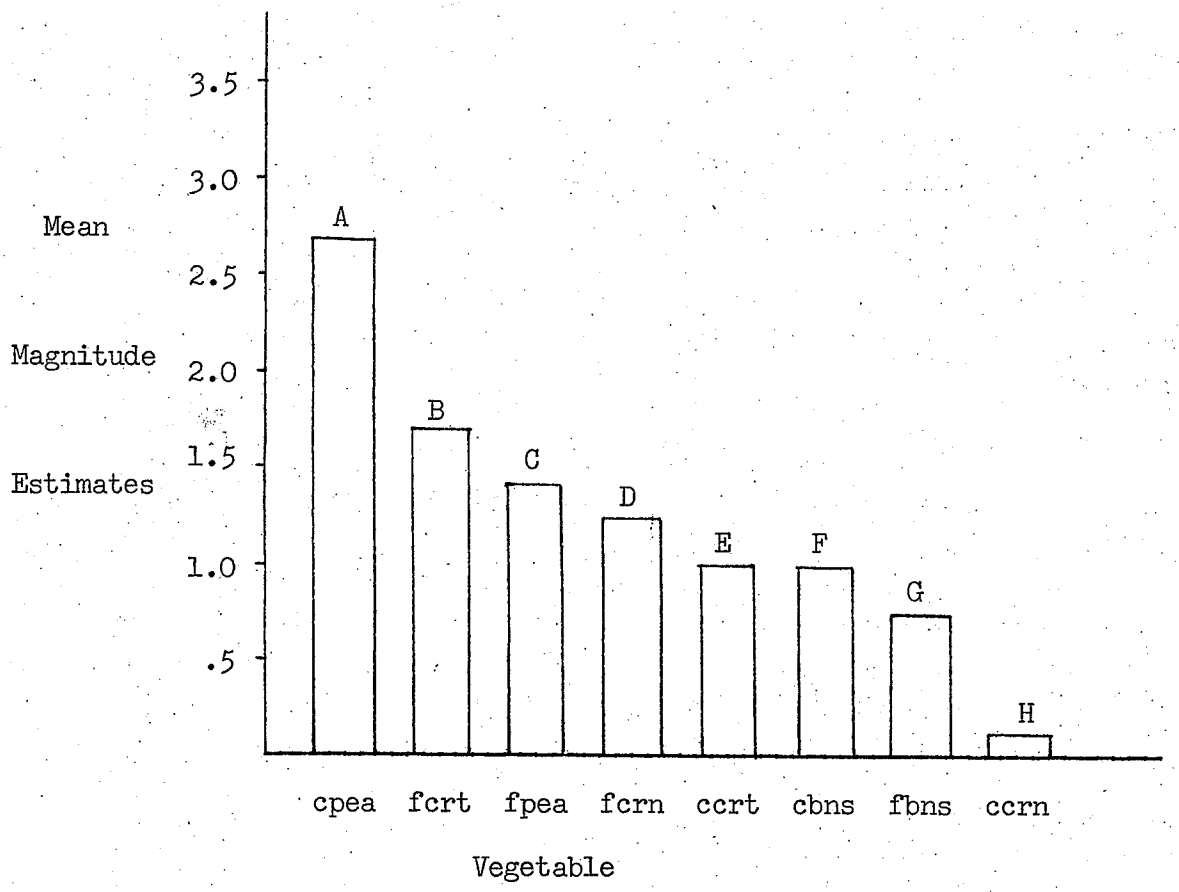
Relationship Between Dryness and Infant Vegetable Preference

There appears to be no relationship between dryness and vegetable preference. Infants exhibit preferences for both the dry and less dry vegetables. The less preferred frozen beans and canned carrots seem to lie about midway between the most and least dry vegetables. The majority of the more preferred vegetables appear on the dryer end of the scale - frozen carrots, frozen corn, and frozen peas. However, canned corn was judged to be the least dry and was frequently found to be significantly preferred.

2. Viscosity

Significant differences in viscosity were found at the one percent level (Appendix R_{ii}). Frozen peas, frozen corn and frozen carrots were the most viscous (Figure 9). They were twice the thickness of canned beans, the reference sample. No difference in

MAGNITUDE ESTIMATES FOR DRYNESS OF PURÉED VEGETABLES



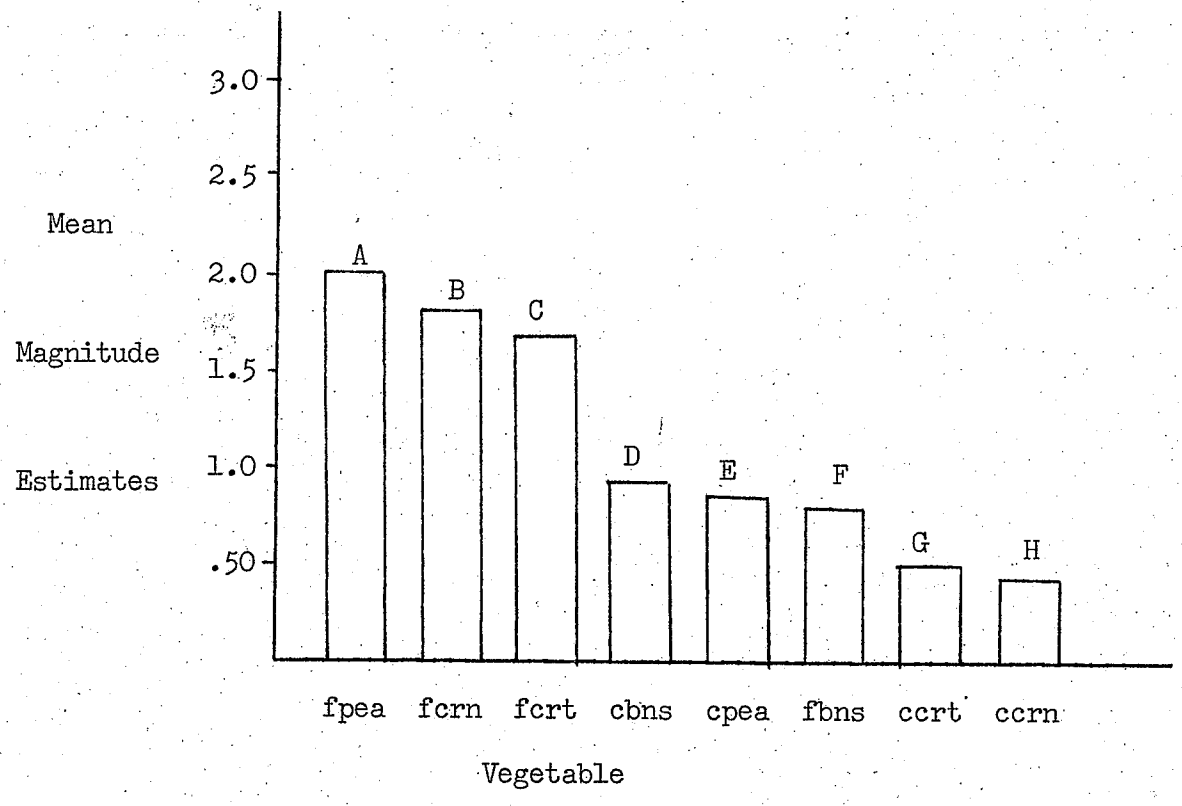
DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D E F G H

Reference = cpea

Figure 8

MAGNITUDE ESTIMATES FOR VISCOSITY OF PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D E F G H

Reference = cbns

Figure 9

viscosity was found for canned beans, frozen beans and canned peas, but these were significantly thicker than canned carrots and canned corn. It appears that the majority of the frozen vegetables were thicker than the canned vegetables.

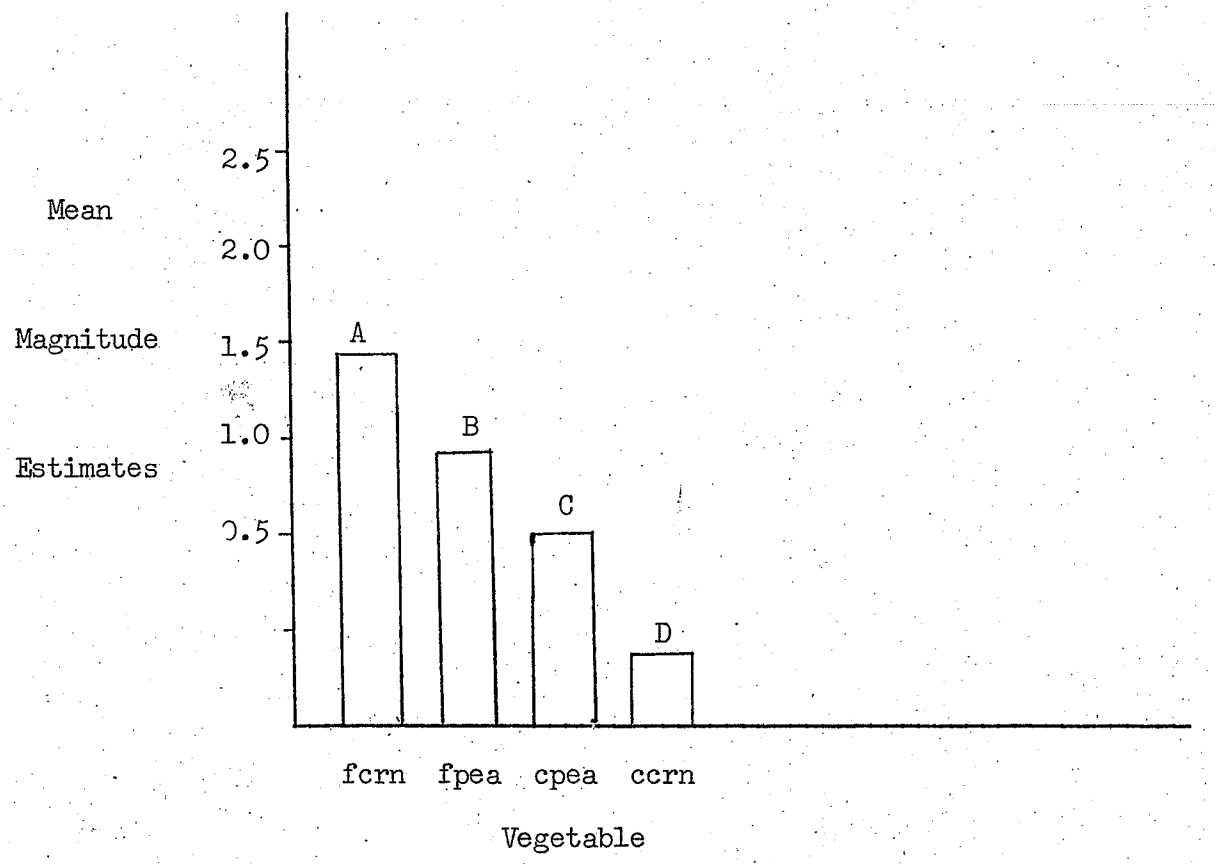
Relationship Between Viscosity and Infant Vegetable Preference

Infants do not appear to be adversely affected by more viscous vegetables, and seem to prefer them. Three of the four vegetables which were most preferred were very thick, while the fourth, canned corn, was one of the thinnest. Preference for thicker vegetables appears more marked with age. Infants in AGE 3 exhibited more preferences for the thicker frozen vegetables than did those in AGE 1. Infants fed vegetables before fruit also prefer the frozen vegetables.

3. Mouthcoat

A significant difference in the dryness of mouthcoat was found (Appendix R_{iii}). Only four vegetables were tested in this category. Frozen corn and frozen peas were estimated to have the highest degree of mouthcoat (Figure 10). Canned peas were half as mouthcoating as frozen corn (reference sample) and canned corn had the least amount.

MAGNITUDE ESTIMATES FOR MOUTHCOAT OF PUREED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D

Reference = cpea

Figure 10

Relationship Between Mouthcoat and Infant Vegetable Preference

With the exception of canned peas, all of these vegetables were among the most frequently preferred vegetables by all subjects. However, the youngest group of infants did not tend to prefer any of these vegetables, while the oldest group of infants tended to prefer all of them. Infants fed vegetables first preferred all these vegetables except canned peas. Those fed fruit before vegetables preferred all except frozen corn. This researcher suspected that vegetables with a high degree of mouthcoat may negatively influence vegetable preference. However, this did not occur.

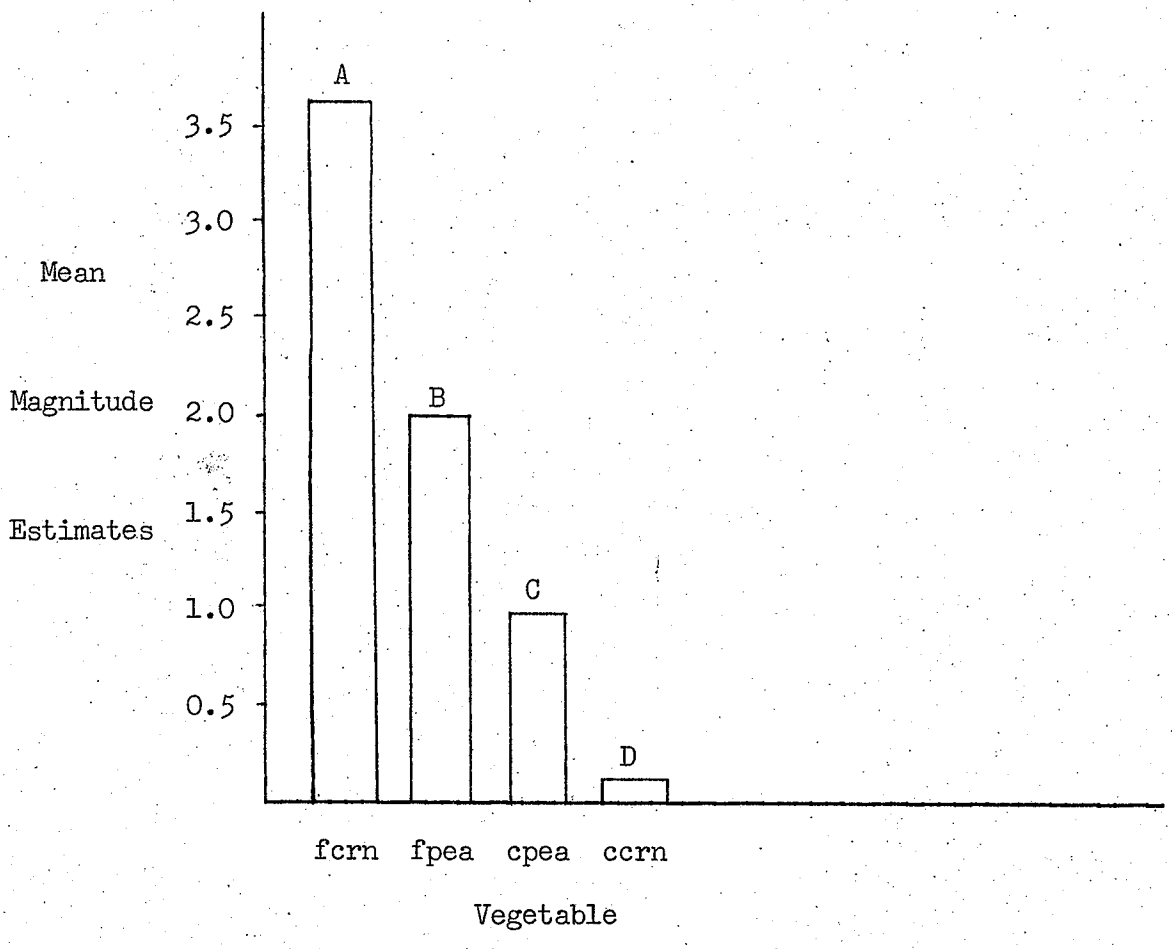
4. Adhesiveness

Analysis of vegetables for adhesiveness resulted in a highly significant difference among those vegetables tested (Appendix R_{iv}). It can be seen in Figure 11 that there was no significant difference in the adhesiveness of frozen corn (reference) and frozen peas. Canned peas were approximately one-third as adhesive as frozen corn. Canned corn was the least adhesive. None of the other vegetables possessed this characteristic.

Relationship Between Adhesiveness and Infant Vegetable Preference

Infants do not appear to be adversely affected by adhesiveness in vegetables. With the exception of canned peas, all these vegetables were most frequently preferred. As the adhesive

MAGNITUDE ESTIMATES FOR ADHESIVENESS OF PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D

Reference = fcrn

Figure 11

vegetables were also found to be mouthcoating, a similar situation exists as mentioned in the above section. Younger infants do not appear to prefer adhesive vegetables while older infants exhibit an increased preference for them. This may be due to the younger infant having more difficulty in manipulating the tongue to remove the adhesive vegetables from the upper palate. The advanced physical development of the older infants may represent an increased ability to orally handle these vegetables. This may also explain why older infants tend to prefer the thicker vegetables.

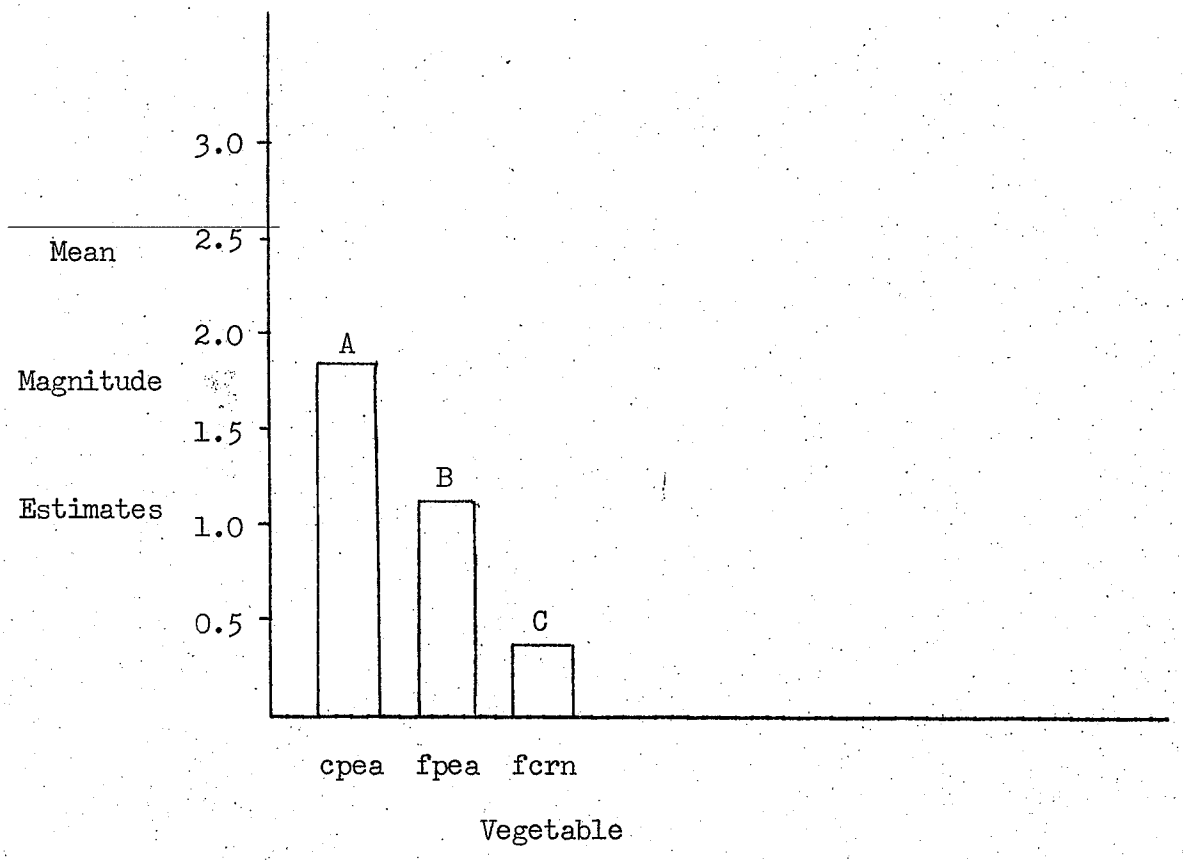
5. Chalkiness

Only three vegetables were analyzed under this parameter and significant differences were found (Appendix R_V). Canned peas (reference sample) were the most chalky, frozen peas half as chalky, and frozen corn was least chalky (Figure 12).

Relationship Between Chalkiness and Infant Vegetable Preference

Preferences for canned peas appeared seldom, thus it may be that their high degree of chalkiness interfered with their acceptance. However, they were seldom found to be less preferred. Only the infants fed vegetables first seemed to dislike canned peas when compared to four other vegetables. Those fed fruit first preferred canned peas on two occasions. Older infants were found to prefer canned peas on two occasions. None of the vegetables least preferred possessed chalkiness. Thus it may be that chalkiness

MAGNITUDE ESTIMATES FOR CHALKINESS OF PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C

Reference = cpea

Figure 12

in vegetables is preferred by infants, or at least is not an important factor in vegetable acceptance.

6. Pulpiness

Four vegetables were analyzed for pulpiness and significant differences were found (Appendix R_{vi}). Frozen carrots had the highest magnitude estimate, but did not differ significantly from canned carrots (Figure 13). Frozen carrots were more pulpy than canned beans (reference) and frozen beans. Frozen beans were judged to be the least pulpy.

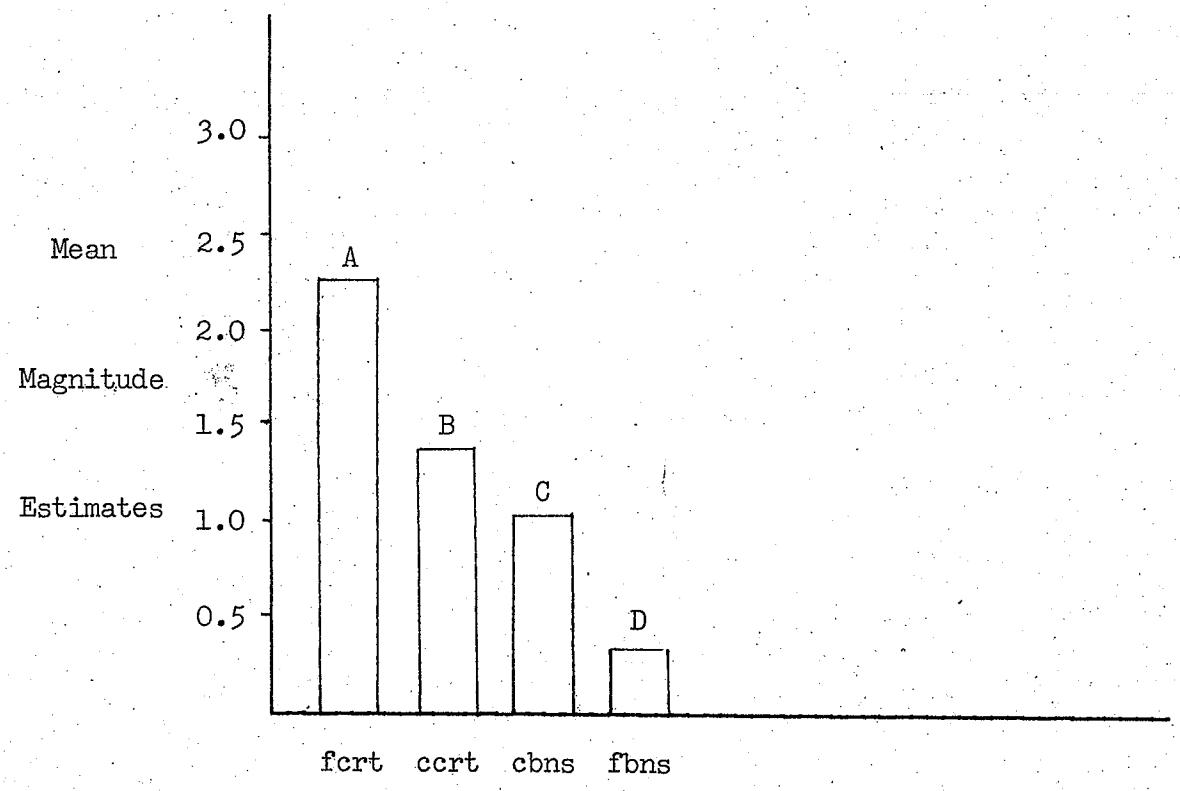
Relationship Between Pulpiness and Infant Vegetable Preference

It appears that pulpiness may interfere with vegetable acceptance. Of the four vegetables possessing pulpiness, two of these were most frequently found to be least preferred - canned carrots and frozen beans. Canned beans were seldom preferred over another vegetable. On the other hand, frozen carrots were often preferred and were considered the most pulpy of all vegetables.

7. Summary of Texture Parameters and Infant Vegetable Preference

It was anticipated that an analysis of the textural characteristics of the vegetable samples and their relationship to infant vegetable preference would provide some insight into infant textural preferences. However, the results of this study are confusing. Infants preferred both the thickest and thinnest

MAGNITUDE ESTIMATES FOR PULPINESS OF PURÉED VEGETABLES



DUNCAN'S MULTIPLE RANGE TEST ($P \leq 0.01$)

A B C D

Reference = cbns

Figure 13

vegetables. The degree of dryness did not appear to affect preference, as both the dry and less dry vegetables were preferred. Various levels of mouthcoat and adhesiveness were found in all vegetables most preferred, but seldom seen in those vegetables least preferred. A greater preference for these vegetables was exhibited by the oldest group of infants. A large amount of chalkiness in canned peas may have adversely affected infant preference for them, but did not interfere with preference for frozen peas. Of those vegetables least preferred, pulipness was a common characteristic. However, frozen carrots which were often preferred, contained the greatest amount of pulpiness. In general, most of the more preferred vegetables were found to be thick, adhesive and mouthcoating.

E. Panelist Assessment of Intensity of Flavor

1. Intensity of Overall Flavor

Panelists rated the vegetables on a nine point category scale on the basis of the intensity of overall flavor (Appendix L). Two replications were conducted. The mean scores for all vegetables are found in Table 12. Panelists agreed that canned carrots and canned peas had the strongest overall flavor (7.50 and 7.42 respectively). Perhaps canned carrots were most frequently disliked by infants because the flavor was too strong. Three of the vegetables preferred by infants were found to have a weak

Table 12

Panelist Assessment of Intensity* of Overall Flavor and Intensity of Vegetable Flavor of Puréed Vegetables

Vegetable	Overall Flavor	Vegetable Flavor
ccrt	7.50	2.42
cpea	7.42	6.67
cbns	6.83	3.25
fpea	6.58	7.67
fbns	5.00	4.08
ccrn	4.75	3.92
fcrt	3.67	7.33
fcrn	3.58	4.67

* 9 point category scale

1 = extremely weak

9 = extremely strong

overall flavor - canned corn, frozen carrots and frozen corn. It is likely, therefore, that infants, like children, prefer milder flavors (Lowenberg, 1948; Glaser, 1964). The vegetable most often disliked was frozen beans. Panelists rated the flavor as being neither weak nor strong. The majority of the canned vegetables tended to be stronger in overall flavor than the frozen vegetables.

2. Intensity of Vegetable Flavor

To determine how closely the taste of each vegetable resembled the vegetable itself, panelists assessed the intensity of vegetable flavor on a nine point category scale (Appendix M). The mean scores are also found in Table 12. The intensity of vegetable flavor was strongest for frozen peas and frozen carrots, and weakest for canned carrots. Frozen corn, frozen beans and canned corn were rated as slightly weak in vegetable flavor. Thus two of the strongest vegetable flavors were preferred and two of the weaker flavors were preferred. This appears to contradict the findings mentioned above. Frozen carrots had a weak overall flavor, but a strong vegetable flavor. In essence, the flavor of frozen carrots was not strong, but it definitely tasted like carrots. Canned carrots, on the other hand, had a strong overall flavor, but the flavor of canned carrots did not appear to resemble carrots. In fact, results of preliminary taste panels found that the majority of panelists were unable to identify canned carrots as such. Frozen beans did not appear to have a particularly strong vegetable flavor nor a strong

overall flavor, but were still disliked.

3. Possible Implications of Flavor Intensity and Infant Vegetable Preferences

The majority of frozen vegetables appeared to be stronger in vegetable flavor than did the canned vegetables. This is an understandable finding as canned vegetables undergo more processing and are less likely to retain their original flavor. This difference in vegetable flavor may be of importance during the transition from pureed vegetables to table vegetables. Infants accustomed to the flavor of frozen vegetables may more readily accept table vegetables which possess a similar flavor. However, infants accustomed to canned pureed vegetables may be less willing to accept the unfamiliar flavor of table vegetables.

F. Pleasantness of Vegetables

Panelists rated each of the vegetables on a nine point category scale for degree of pleasantness (Appendix K). Table 13 shows the order of infant and panelist preference for vegetables. Panelists do not appear to find canned corn as pleasant as the infants, nor frozen beans as unpleasant. There is some similarity in the order of preference for frozen peas, frozen carrots and frozen corn, suggesting that infant preferences may be similar to adults. Canned beans and canned carrots were less liked by both groups. However,

Table 13

Order of Vegetable Preference by Adult Panelists and Infants

Panelists	Infants
Order of Preference	Order of Preference
fpea	fcrn
fcrt	ccrn
fcrn	fcrt
fbns	fpea
ccrn	cpea
cbns	cbns
ccrt	ccrt
cpea	fbns

infants did not appear to find canned peas as unpleasant as adults. It was not possible to statistically analyze these results together as the scales used were different.

G. Comparison of Canned and Frozen Vegetables

There was no significant difference in preference for canned or frozen vegetables by all subjects. From the results of the sensory analysis, there seems to be some major differences between the two types. The majority of canned vegetables were rated higher in sweetness than frozen vegetables. Manufacturers add sugar to these vegetables except for canned peas and beans. As infants do not necessarily prefer the sweeter vegetable, one may question the reasoning behind this. Canned vegetables appear to contain much higher levels of bitterness than frozen vegetables. Sourness was perceived in only the canned vegetables. Frozen vegetables tend to be more viscous than canned. At the time of preparation, the viscosity was comparable to canned vegetables. However, after the freezing process, they appeared thicker. Excluding canned peas, the majority of frozen vegetables were considered more dry than the canned vegetables. Both forms of peas and corn were mouthcoating and adhesive. Canned and frozen peas were chalky, while both forms of beans and carrots were pulpy. The overall flavor for canned vegetables appears more intense, while the actual vegetable flavor for canned is weaker. Panelists found the frozen vegetables

to be more pleasant than the canned.

The only significant preference for frozen vegetables over canned occurred with those infants fed vegetables before fruit. Perhaps because they were unaccustomed to the sweet taste of fruit, they were more partial to the less sweet frozen vegetables. A lower preference for canned carrots and canned peas was exhibited by the VEG 1 group, but this was not seen by the infants fed fruit first. Of those vegetables preferred by VEG 2 infants, the majority were canned. This may be due to the higher sweetness level or it may be a result of the lower viscosity level. If the majority of infants were fed commercially prepared fruits, the viscosity may be similar to that of canned vegetables. Thus being more familiar with a less viscous consistency, the thicker frozen vegetables may not have been as well accepted.

H. Relationship Between Results and Major Hypotheses

(a) Infants will exhibit likes and dislikes for vegetables.

From the results of this study, it can be concluded that infants like and dislike certain vegetables. The nature of the study was such that it cannot be determined whether these preferences were the result of taste, texture, or more possibly, a combination of the two. Frozen corn, canned corn, frozen carrots, and to some extent, frozen peas, were most frequently preferred or suggested to be preferred. Frozen beans were significantly less preferred

and a trend for lower preference for canned carrots was also seen.

(b) Acceptance of vegetables by infants in general will be low.

The results of this study show that vegetables were not received enthusiastically by all infants. However, the majority of mean preference scores were above the "indifferent" score (three) and bordering on "seems to like" (four). Thus this hypothesis must be rejected.

(c) Infants will exhibit greater preference for frozen vegetables than for canned vegetables.

There was no significant differences in preferences for canned or frozen vegetables by all subjects, nor for any of the age groups. Infants fed vegetables first preferred frozen vegetables over canned. In individual comparisons for each set of hypotheses tested, frozen vegetables were more frequently found to be preferred. It is possible that the consistently low preference for frozen beans resulted in masking a significant preference for frozen vegetables over canned vegetables.

(d) Older infants will exhibit more vegetable preferences than younger infants.

This hypothesis can be accepted when suggested trends are considered. The youngest group of infants showed less likes and dislikes while the oldest group seemed more definite about their

preferences. Thus it appears that as an infant gets older, he becomes more discriminating in his vegetable preference.

(e) Infants fed fruits before vegetables will have a lower preference for vegetables than those fed vegetables first.

Neither group differed significantly in their preference for canned vegetables. Infants fed vegetables first however, significantly preferred frozen vegetables over those fed fruit first. Infants fed vegetables first also preferred frozen over canned. These infants also had higher mean preference scores for six out of eight vegetables. This suggests then that infants fed vegetables first prefer vegetables more than those fed fruits.

(f) There will be some sensory link between those vegetables liked and those disliked.

From the results of this study, it is not possible to accept this hypothesis. Those vegetables liked and disliked are not bound by one common characteristic. However, the majority of preferred vegetables tend to be thicker, mouthcoating and adhesive. Less preferred vegetables appear to be pulpy.

SUMMARY AND CONCLUSIONS

Forty-three infants within The City of Winnipeg, participated in a twenty-four day study designed to determine infant acceptance of vegetables.

Information on infant feeding practices prior to the introduction of vegetables was obtained. It was found that solids are still being introduced at ages much earlier than what is deemed nutritionally necessary.

The data from thirty-eight infants who successfully completed the vegetable study were analyzed. No significant differences in preferences for canned or frozen puréed vegetables by all subjects, were found. However, infants fed vegetables first, significantly preferred the frozen vegetables more than the canned. In addition, their preference for vegetables in general, appeared greater than those fed fruit before vegetables. Older infants appeared to be more discriminating and exhibited more vegetable preferences than younger infants did.

In general, both canned and frozen corn were most preferred, while frozen beans and canned carrots were less preferred. Frozen peas and frozen carrots were also found to be more frequently preferred by the majority of infants.

A trained adult panel used magnitude estimation to scale the sensory characteristics of puréed vegetables. Panel results were

coupled with infant responses. It was found that infants do not necessarily prefer the sweet-tasting vegetables. The degree of sourness and bitterness may adversely affect vegetable preference. An evaluation of the textural characteristics suggests that infants tend to prefer vegetables that are thick, mouthcoating and adhesive.

Results suggest that infant vegetable preferences are not based on taste alone. Further research should be directed toward infant textural preferences.

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A P P E N D I C E S

THE UNIVERSITY OF MANITOBA
FACULTY OF HOME ECONOMICS
WINNIPEG, CANADA R3T 2N2
TELEPHONE 204 474-9913

APPENDIX A

As a graduate student with the Department of Foods and Nutrition, University of Manitoba, I am involved in a research project on infant feeding. I am especially interested in the acceptance of vegetables by infants.

It is known that many pre-school children do not like vegetables, however, very little information is available on infant food preferences. It is hoped that with your assistance, this study will provide more information in this area.

Approximately fifty infants, less than six months old and having had no previous exposure to vegetables, will be needed for the study. The study has been approved by Dr. D. Grewar, Department Head of Pediatrics at the St. Boniface Hospital. Your name has been forwarded to me by the Pre-Natal Clinic at the St. Boniface Hospital with the information that you now have or will soon have an infant at home and that you may be interested in joining the study.

The study will run approximately twenty-four days, during which time all vegetables will be supplied to you at no charge. You will be free to begin at any time you or your physician feel your infant is ready to accept vegetables. The program is designed so that you will not be inconvenienced by any changes in your daily routine.

Your participation is, of course, completely voluntary. I sincerely hope that you will seriously consider assisting me with this study. Within the next few days, I shall contact you by telephone to learn of your interest. At that time, I would be pleased to arrange to meet with you at your convenience to discuss complete details of the program.

In the meantime, thank you very much for your attention and I look forward to meeting with you.

Yours truly,

LH/dm

(Miss) Lynn Harasym
Graduate Student

APPENDIX B

Instructions for Preparation of Puréed Vegetables

Puréed Peas

2 1/2 lb. frozen peas
2 cups boiling water

Add peas to boiling water, cover and return to boil. Reduce heat and boil gently for six minutes. Drain peas, reserving 1 1/2 cups cooking water. Blend peas and water at high speed for three-one minute intervals, stirring at each interval.

Puréed Carrots

2 1/2 lb. frozen sliced carrots
2 cups boiling water

Add carrots to boiling water, cover and return to boil. Reduce heat and boil gently for eight minutes. Drain carrots, reserving 1 1/4 cups cooking water. Blend carrots and water at high speed for three-one minute intervals, stirring at each interval.

Puréed Green Beans

2 1/2 lb. frozen green beans
2 cups boiling water

Add beans to boiling water, cover and return to boil. Reduce heat and boil gently for twelve minutes. Drain beans, reserving 1 1/4 cups cooking water. Blend beans and water at high speed for four-one minute intervals, stirring at each interval. Force puréed beans through a sieve to remove fibrous particles.

Puréed Corn

2 1/2 lb. frozen corn niblets
2 cups boiling water

Add corn to boiling water, cover and return to boil. Reduce heat and boil gently for six minutes. Drain corn. Do not reserve cooking water. Blend corn at low speed for three-one minute intervals, stirring at each interval. Force puréed corn through a sieve to remove fibrous particles.

THE UNIVERSITY OF MANITOBA
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TELEPHONE 204 474-9913

APPENDIX C

Dear Parent:

I am very pleased to welcome you and your baby to this study. Your participation in this project is greatly appreciated.

If you should have any questions regarding the procedures involved, please do not hesitate to call me at 474-9954, 474-9498, or 474-9901. As I will be out of town for the month of September, please direct any questions at this time to Dr. M. McDaniel at 474-9498 or 474-9901.

As soon as you have completed the study, please call me and I will arrange to pick up the questionnaire and observation sheets. Once all the data has been collected and analyzed, you will be informed of the results.

In the meantime, I trust both you and your baby will enjoy being on the study, and once again, thank you for your co-operation.

Yours truly,

LH/jw

Lynn Harasym,
Graduate Student.

APPENDIX D

Schedule #5

Days	Vegetable	Form
1, 2, 3	Peas	Canned
4, 5, 6	Peas	Frozen
7, 8, 9	Corn	Canned
10, 11, 12	Corn	Frozen
13, 14, 15	Carrots	Frozen
16, 17, 18	Carrots	Canned
19, 20, 21	Beans	Frozen
22, 23, 24	Beans	Canned

APPENDIX E

Instructions

A. Storage, Preparation and Serving of Vegetables

I. Canned Vegetables

1. Store unopened jars at room temperature.

2. Jars should open with a "pop" sound. If they do not, then discard the jar and contact me as soon as possible for another sample.

3. Store opened jars in the refrigerator and discard after three days.

4. Heat a small amount of vegetable in a baby food warming dish or in a custard cup set in a pan of hot water.

5. Do not heat entire jar and do not feed baby directly from the jar.

II. Frozen Vegetables

1. Keep all samples frozen until ready for use.

2. Remove vegetable from wax-coated container before heating. The container is easily removed if the sample is left to thaw slightly in the refrigerator.

3. If you wish to thaw the vegetable completely, this must be done in the refrigerator, and not at room temperature.

4. Heat the entire sample in a baby food warming dish or in a custard cup set in a pan of hot water.

5. Discard any portion uneaten.

It is recommended that you:

1. Serve the scheduled vegetable once each day, preferably at lunch time.
2. Do not taste the vegetable first.
3. Serve each vegetable in the same manner throughout the entire study. Any change in your own attitude towards the vegetable may influence your baby's acceptance or rejection.
4. Do not disguise the taste of the vegetable by mixing it with some other food.

5. Offer the vegetable several times, but do not force-feed.
6. If fruits are included in the feeding, serve them after the vegetable.

B. Questionnaire

Complete the attached questionnaire on the first day of the study, that is, the day you begin to feed vegetables to your baby.

C. Observation Sheet

1. Complete this sheet immediately after a vegetable is consumed. There are 24 observation sheets - one for each day of the study.

2. Record the time of feeding and list those foods and liquids fed before and after each vegetable.

3. Estimate the amount of vegetable eaten each time. The teaspoon measure listed is that of a normal household teaspoon and not a baby's teaspoon.

4. Observe and record all facial expressions, sounds or any other clues your baby may give to tell you he likes or dislikes the vegetables.

5. Comment whether each day is a healthy, normal feeding situation, or if your baby is not well, for example, suffering with a cold, flu, colic, teething, etc.

Any other information that you feel is important, may be recorded under "Comments" on the Observation Sheet.

Note:

If your baby shows an allergic response to one vegetable, stop serving it, wait a few days and then introduce the next vegetable. Be sure to record this allergy on the Observation Sheet.

You may notice a change in the color and consistency of your baby's stools after feeding a new vegetable, however, this is a normal reaction.

APPENDIX F

Questionnaire

1. Name of Parents _____
2. Address _____
3. Telephone Number _____
4. Name of Infant _____ Sex M _____ F _____
5. Date of Birth _____
6. Weight at Birth _____
7. Present Age _____
8. Present Weight _____
9. What type of milk was used for feeding at birth? _____

   _____

   _____
10. What type of milk is used for feeding at the present time? _____

    _____

    _____
11. Has your baby been introduced to fruit juices? Yes _____ No _____

    If yes, at what age and what type of juice was served first.

    Age _____ Juice _____
12. How did your baby react to this juice?

    ( ) Liked it and drank all that was offered
    ( ) Liked it, but drank only a small amount
    ( ) Disliked it, but drank some
    ( ) Disliked it and refused to drink

13. What <u>other</u> fruit juices has your baby had?

( ) Grapefruit
( ) Prune
( ) Tomato
( ) Orange
( ) Apple
( ) Pineapple
( ) Pear
( ) Other (Specify)_____

14. What juice(s) does your baby prefer?_____

_____

_____

15. What juice(s) does your baby dislike?_____

_____

_____

16. How did you decide when your baby was ready to eat solids?

( ) Books, magazines
( ) Relatives and friends
( ) Physician's advice
( ) Pre-natal Clinic
( ) Public Health Nurse
( ) Personal experience
( ) Other (Specify)_____

17. Have cereals been introduced? Yes_____No_____

If yes, at what age and what type of cereal was served?

Age_____Cereal_____

18. How did your baby react to this cereal?

( ) Liked it and ate all that was offered
( ) Liked it, but ate only a small amount
( ) Disliked it but ate some
( ) Disliked it and refused to eat

19. Have fruits been introduced? Yes_____ No_____

If yes, at what age and what type of fruit was served first?

Age_____ Fruit_____

20. Was this fruit prepared at home or was it a commercial product?

_____

21. How did your baby react to this fruit?

( ) Liked it and ate all that was offered
( ) Liked it, but ate only a small amount
( ) Disliked it but ate some
( ) Disliked it and refused to eat

22. What other fruits have you served?

( ) Apricots
( ) Peaches
( ) Plums
( ) Pineapple
( ) Applesauce
( ) Prunes
( ) Pears
( ) Bananas
( ) Other (Specify)_____

23. What fruit(s) does your baby prefer?_____

_____

_____

24. What fruit(s) does your baby dislike?_____

_____

_____

25. Have meats been introduced? Yes_____ No_____

If yes, at what age and what type of meat was served first?

Age_____ Meat_____

26. Was this meat prepared at home or was it a commercial product?

_____

27. How did your baby react to this meat?

( ) Liked it and ate all that was offered
( ) Liked it but ate only a small amount
( ) Disliked it, but ate some
( ) Disliked it and refused to eat

28. What other meats have you served?

( ) Beef
( ) Chicken
( ) Lamb
( ) Veal
( ) Ham
( ) Beef liver
( ) Other (Specify)_____

29. What meat(s) does your baby prefer:_____

_____

30. What meat(s) does your baby dislike?_____

_____

APPENDIX G

Observation Sheet

(Day_____of Schedule_____)

Date_____

Name_____

Vegetable to be served_____

Time of feeding_____

List the foods and liquids fed before this vegetable_____

_____

List the foods and liquids fed after this vegetable_____

_____

Was the vegetable accepted? Yes_____No_____

If yes, estimate the amount eaten:

( ) less than 1/2 teaspoon
( ) 1/2 - 1 teaspoon
( ) 1 - 2 teaspoons
( ) 2 - 3 teaspoons
( ) more than 1 tablespoon

Briefly describe your baby's reaction to this vegetable. What did your baby do to let you know that he/she liked or disliked the vegetable.

_____

_____

Is your baby feeling well today? Yes_____No_____

If no, please explain_____

_____

Comments_____

_____

APPENDIX H

Taste Intensity of Puréed Vegetables

Using magnitude estimation, estimate the amount of sweetness, sourness and bitterness in each of the samples. Assign each of the reference samples a score of 20. Score each sample in relation to the reference. If the taste is not present, use NP.*

Rest between samples. Stir before tasting.

	Sample No.	Score
$R_1 = 20$	_____	_____
	_____	_____
	_____	_____
	_____	_____
$R_2 = 20$	_____	_____
	_____	_____
	_____	_____
	_____	_____
$R_3 = 20$	_____	_____
	_____	_____
	_____	_____
	_____	_____

* Not Present

APPENDIX I

Texture Evaluation of Puréed Vegetables

Assign each reference sample a score of 20. Using magnitude estimation, estimate the textural characteristics of each of the samples in relation to the reference. Study each definition and be sure to use the same technique when evaluating each sample.

Expectorate all samples except where indicated. Stir before tasting.

VISCOSITY: Place sample in mouth and measure the force required to make sample flow between tongue and palate.

$R_4 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

CHALKINESS: Place sample on tip of tongue; gently push tongue out, touching upper lip. Estimate the amount of very small particles in mouth.

$R_5 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

MOUTHCOAT: Place sample in mouth and swirl. Evaluate the amount of mouthcoat immediately after expectorating. Use a cracker between samples.

$R_5 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

ADHESIVENESS: Place sample in mouth and measure the amount of force required to remove sample that sticks to palate.

$R_6 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

DRYNESS: Place sample in mouth and estimate the overall reduction of fluids in mouth before and after swallowing. Do not expectorate.

$R_5 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

PULPINESS: Place sample in mouth and estimate the size of soft cellular particles (i.e. pulpiness).

$R_1 = 20$

_____	_____
_____	_____
_____	_____
_____	_____

APPENDIX J

Pleasantness of Reference Taste Solutions

According to the following scale, rate the degree of pleasantness for each of the reference solutions.

9 - extremely pleasant

8 - very pleasant

7 - pleasant

6 - slightly pleasant

5 - neither pleasant nor unpleasant

4 - slightly unpleasant

3 - unpleasant

2 - very unpleasant

1 - extremely unpleasant

R_1 = _____

R_2 = _____

R_3 = _____

APPENDIX K

Pleasantness of Puréed Vegetables

According to the following scale, rate the degree of pleasantness for each of the coded samples.

9 - extremely pleasant

8 - very pleasant

7 - pleasant

6 - slightly pleasant

5 - neither pleasant nor unpleasant

4 - slightly unpleasant

3 - unpleasant

2 - very unpleasant

1 - extremely unpleasant

Sample No.	Degree of Pleasantness
_____	_____
_____	_____
_____	_____
_____	_____

APPENDIX L

Intensity of Overall Flavor of Puréed Vegetables

According to the following scale, rate the overall flavor intensity of each of the coded samples.

9 - extremely strong

8 - very strong

7 - strong

6 - slightly strong

5 - neither strong nor weak

4 - slightly weak

3 - weak

2 - very weak

1 - extremely weak

Sample No.	Flavor Intensity
_____	_____
_____	_____
_____	_____
_____	_____

APPENDIX M

Intensity of Vegetable Flavor of Puréed Vegetables

Rate the intensity of vegetable flavor for each of the coded samples.

9 - extremely strong

8 - very strong

7 - strong

6 - slightly strong

5 - neither strong nor weak

4 - slightly weak

3 - weak

2 - very weak

1 - extremely weak

Sample No.	Flavor Intensity
_____	_____
_____	_____
_____	_____
_____	_____

APPENDIX N

Concentrations* of Taste Stimuli Used in Determination of Power Functions

% Sucrose	% Citric Acid	% Caffeine
12.0	0.8	0.8
8.0	0.4	0.4
4.0	0.2	0.2
2.0	0.1	0.09
1.0	0.05	0.05
0.5	0.025	0.025
0.25	0.010	0.010

* Weight by volume in tap-distilled water

APPENDIX O

Power Functions

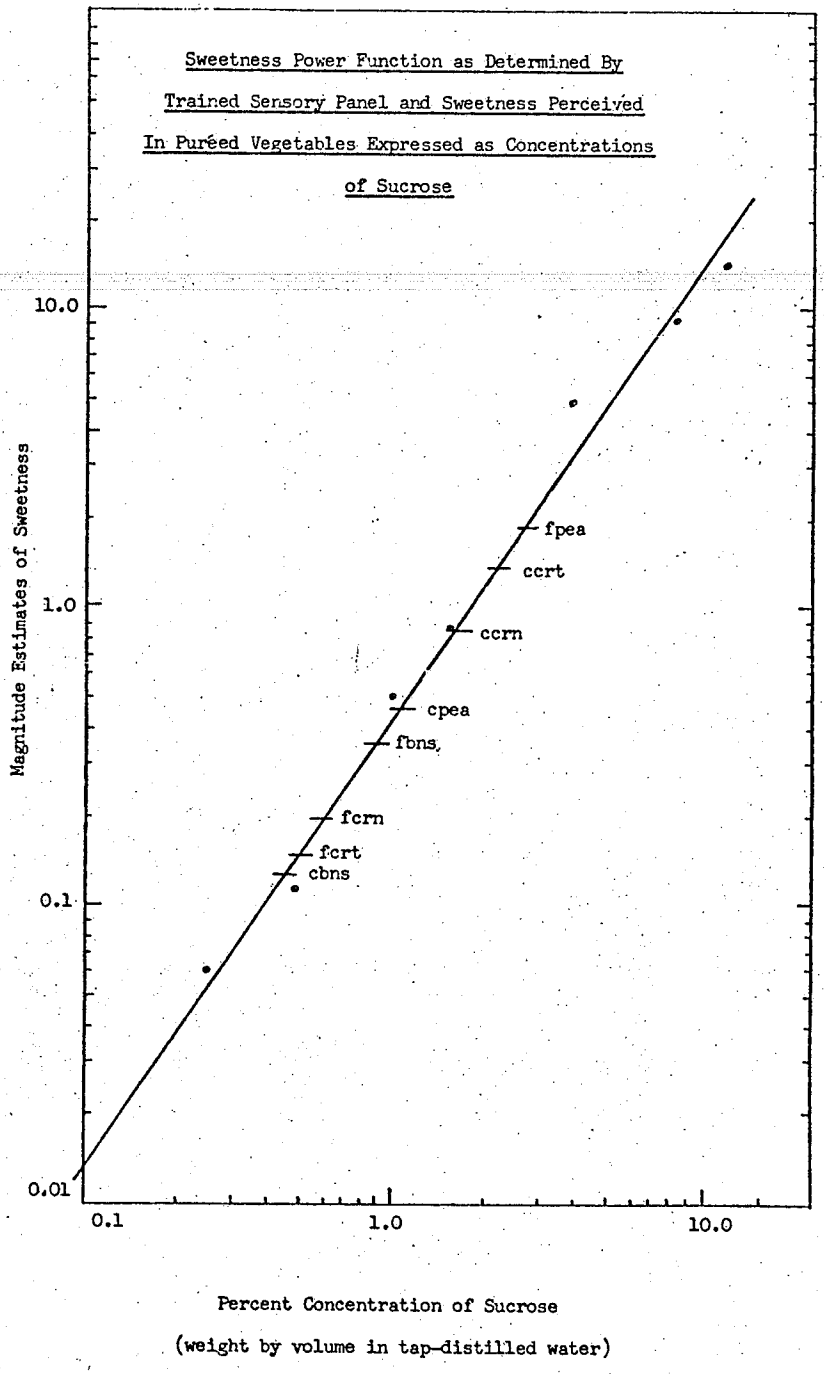
Taste the reference sample and assign it a score of 20. Taste each of the coded samples. Estimate the magnitude of sweetness, sourness and bitterness of the coded samples in relation to the reference. Rest between samples.

Sample Code	Score
R_1	20

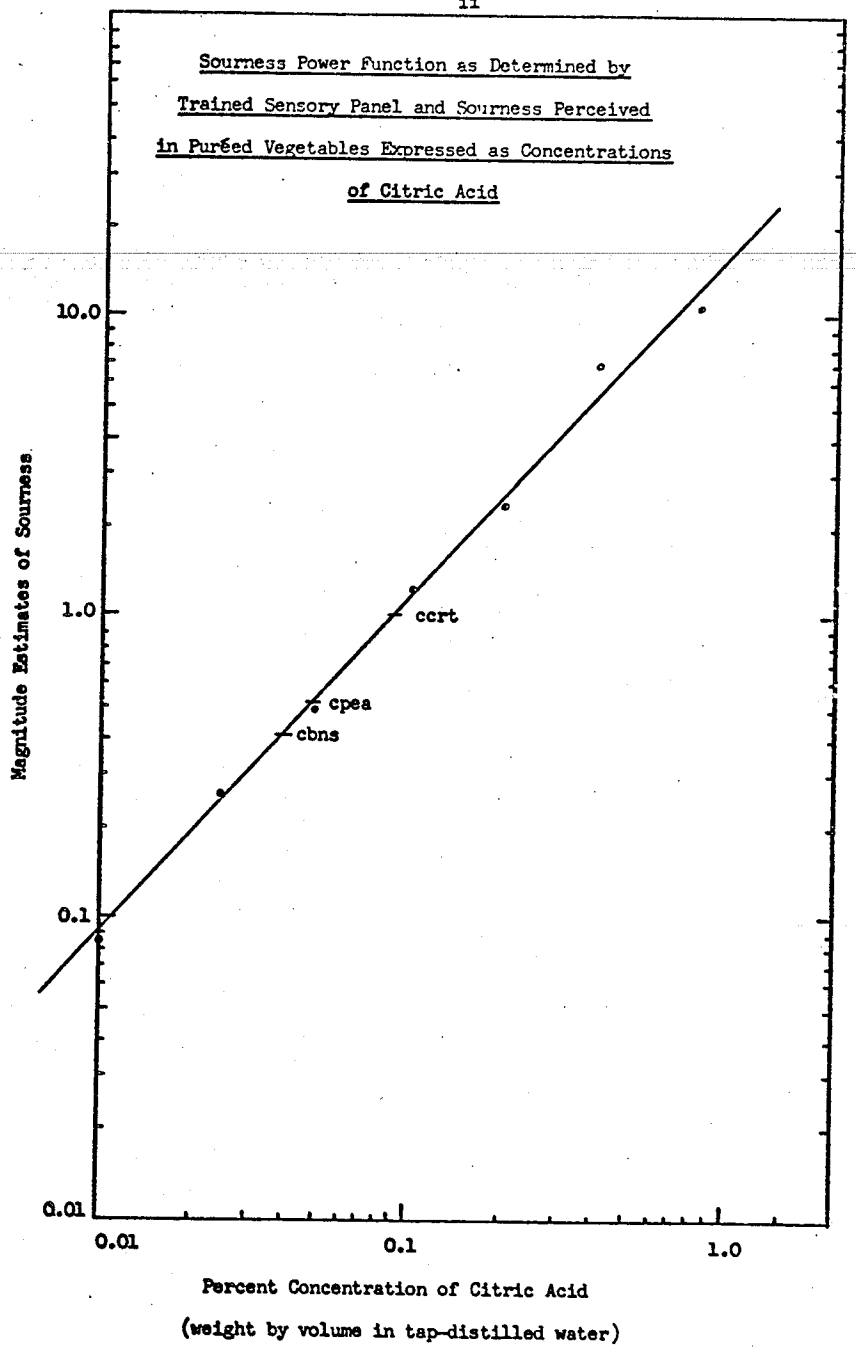
Sample Code	Score
R_2	20

Sample Code	Score
R_3	20

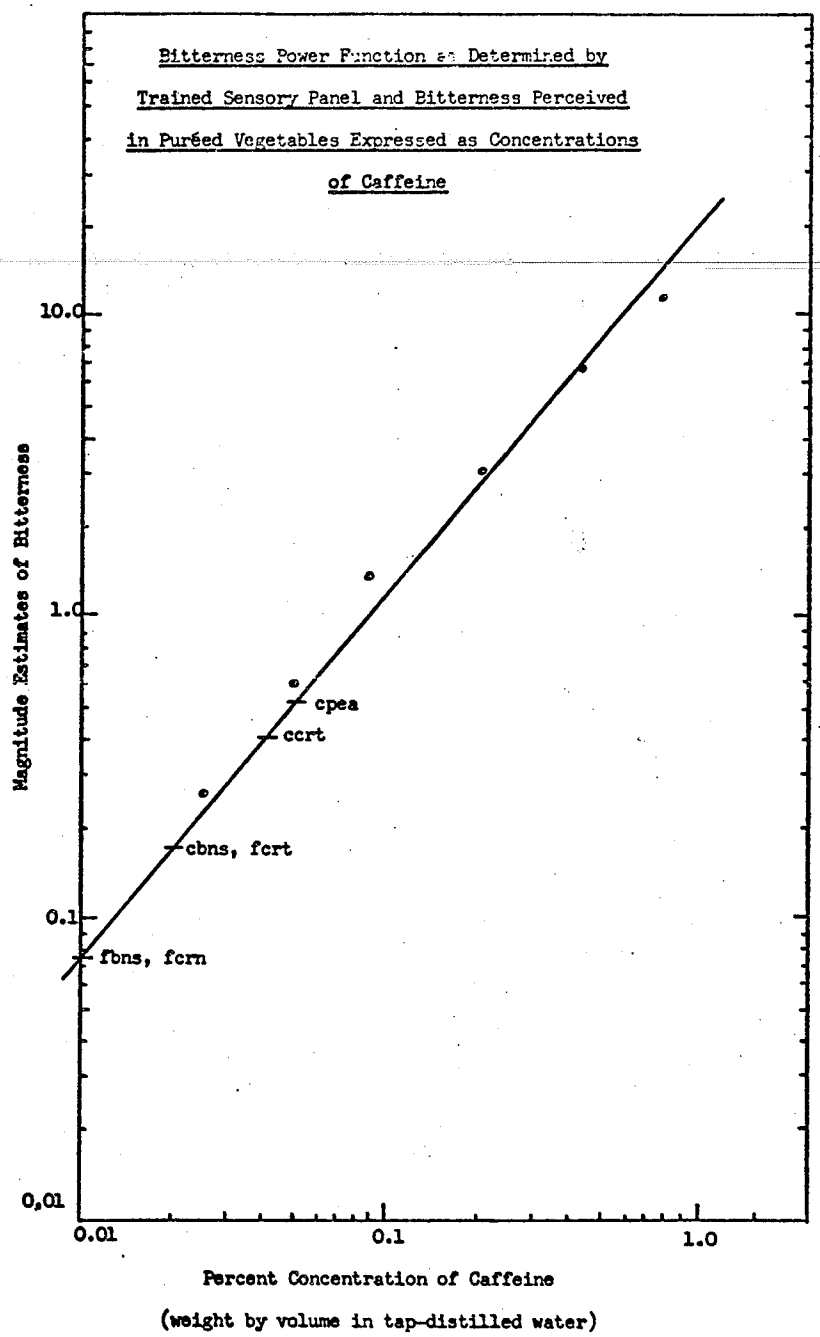
APPENDIX P_i


Sweetness Power Function as Determined By
Trained Sensory Panel and Sweetness Perceived
In Puréed Vegetables Expressed as Concentrations
of Sucrose
Magnitude Estimates of Sweetness
10.0
1.0
0.1
0.01
0.1
1.0
10.0
fpea
ccrt
ccrn
cpea
fbns
fcrn
fcrt
cbns
Percent Concentration of Sucrose
(weight by volume in tap-distilled water)

APPENDIX P_{ii}



APPENDIX P_{iii}



APPENDIX Q

(i) Analysis of Variance for Sweetness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.078	0.016	0.29	n.s.
Vegetables	8	19.886	2.486	45.60	0.01
Interaction (Veg. X Panelists)	40	11.901	0.298	5.46	0.01
Error	54	2.944	0.055		
Total	107	34.809			

(ii) Analysis of Variance for Sourness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.002	0.000	0.02	n.s.
Vegetables	3	1.536	0.512	28.88	0.01
Interaction (Veg. X Panelists)	15	0.775	0.052	2.91	0.01
Error	24	0.426	0.018		
Total	47	2.739			

(iii) Analysis of Variance for Bitterness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.000	0.000	0.00	n.s.
Vegetables	6	18.659	3.110	81.17	< 0.01
Interaction (Veg. X Panelists)	30	8.408	0.208	7.32	< 0.01
Error	42	1.609	0.038		
Total	83	28.676			

APPENDIX R

(i) Analysis of Variance for Dryness in Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.001	0.000	0.01	n.s.
Vegetables	7	11.980	1.711	61.33	< 0.01
Interaction (Veg. X Panelists)	35	6.513	0.186	6.67	< 0.01
Error	48	1.339	0.028		
Total	95	19.833			

(ii) Analysis of Variance for Viscosity of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.017	0.003	0.29	n.s.
Vegetables	7	5.342	0.763	67.59	< 0.01
Interaction (Veg. X Panelists)	35	1.389	0.040	3.51	< 0.01
Error	48	0.542	0.011		
Total	95	7.289			

(iii) Analysis of Variance for Mouthcoat of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.015	0.003	0.36	n.s.
Vegetables	3	3.791	1.264	145.18	< 0.01
Interaction (Veg. X Panelists)	15	0.416	0.028	3.19	< 0.01
Error	24	0.209	0.009		
Total	47	4.432			

(iv) Analysis of Variance for Adhesiveness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.010	0.002	0.04	n.s.
Vegetables	3	14.247	4.749	98.10	< 0.01
Interaction (Veg. X Panelists)	15	3.089	0.206	4.25	< 0.01
Error	24	1.162	0.048		
Total	47	18.508			

(v) Analysis of Variance for Chalkiness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.000	0.000	0.00	n.s.
Vegetables	2	3.756	1.878	195.80	< 0.01
Interaction (Veg. X Panelists)	10	0.473	0.047	4.93	< 0.01
Error	18	0.173	0.010		
Total	35	4.402			

(vi) Analysis of Variance for Pulpiness of Puréed Vegetables

Source of Variance	df	SS	MS	F	Probability
Panelists	5	0.000	0.000	0.00	n.s.
Vegetables	3	4.401	1.467	67.38	< 0.01
Interaction (Veg. X Panelists)	15	0.936	0.062	2.87	n.s.
Error	24	0.523	0.022		
Total	47	5.860			