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INFANT ACCEPTANCE AND TRAINED PANEL EVALUATION OF MODEL TASTE AND TEXTURE SYSTEMS

by

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ABSTRACT

Infant Acceptance and Trained Panel Evaluation of

Model Taste and Texture Systems

It has been demonstrated that infants exhibit food preferences. However, the influence of taste and texture on these preferences has not been established. Six bland texture systems were prepared from naturally occurring foods. The systems were developed by a trained sensory panel to copy the intensities of six selected combinations of textural characteristics encountered in Heinz infant foods. The panel also established the maximum perceived intensities of sweetness, sourness and bitterness found in Heinz infant foods in terms of their corresponding percent sucrose, citric acid and caffeine concentrations respectively. Each of these taste intensities was represented in one of the texture systems thus creating a sweet, sour and bitter treatment. The sensory characteristics of the treatments were defined using a trained sensory panel. Forty-nine five to eight month old infants participated in an eighteen day study to determine infant acceptance of the nine model taste and texture systems. The infants preferred the sweet and the smooth textured systems ($p = 0.05$). Sourness adversely affected food acceptance ($p = 0.05$). Pulpy textured foods and those containing a small number of small particles were as favorably accepted by the infants as smooth textured foods.

Infant acceptance decreased as the size and number of particles in a food increased ($p = 0.05$). Both taste and texture significantly affected the acceptance of puréed foods by infants.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

Page

INTRODUCTION

Food preferences of infants between the ages of four and ten months have been ignored by researchers. Currently, semi-solid foods ranging in taste and textural characteristics are introduced to infants as early as the first month of life. It has generally been assumed that before ten months of age, infants do not exhibit any food preferences. However, limited infant feeding surveys have indicated that distinct food preferences exist.

It is known that infants respond to sour and bitter stimuli and show a distinct preference for sweet stimuli. In addition, texture is known to influence the food preferences of children and adults. The effect of texture on infant food preferences is unknown. Food habit formation may be rooted in early eating experiences and may be influenced by taste and texture. Therefore, this study was designed to investigate the influence of taste and texture on infant acceptance of puréed food systems. The objectives were:

1. To represent the predominant textural characteristics found in H. J. Heinz Company strained infant foods in odorless, bland tasting systems prepared from naturally occurring foods.
2. To determine infant acceptance of these texture systems.

3. To determine infant acceptance of sweet, sour and bitter systems.

4. To determine and relate selected background feeding practices of the infants to their acceptance of the systems.

5. To define the sensory characteristics of the model systems and relate them to infant acceptance.

REVIEW OF LITERATURE

I. INFLUENCE OF TEXTURE ON FOOD ACCEPTANCE BY INFANTS

Szczesniak (1972) reported that texture is an important attribute influencing the food preferences of children. Generally, their preferences follow the course of physiological development. They like simple, one-dimensional textures and reject those which are difficult to control in the mouth at a particular stage of physical development.

There is a decided lack of literature concerned with the texture preferences of infants less than one year of age. Subjects for studies in this area are generally two years of age or older. To the best of this author's knowledge, no study has directly investigated the effect of texture on the acceptance of semi-solid foods by infants. The inability of infants to vocalize is undoubtedly a major factor limiting work in this area.

A. Infant Food Preferences

Anderson (1977), Szczesniak (1972) and Lowenberg (1953) infer that until infants are ten months old, they do not indicate any food preferences. Harasym (1977), however, found that infants six to nineteen weeks of age demonstrated vegetable preferences. In addition, this author concluded that these preferences are not based on taste alone.

Some information on the food preferences of infants less than one year of age is provided by investigations of infant feeding practices. The criteria used for determining food preferences were not reported. This author assumed that frequency of use reflected degree of infant acceptance. Ferris et al (1978b), Maslansky et al (1974) and Harris and Chan (1969) surveyed over two hundred mothers on infant feeding practices. Rice was reported to be the most frequently used cereal initially (Ferris et al, 1978b; Harris and Chan, 1969). Applesauce and banana were consistently the most popular fruits. This finding agrees with that of Beal (1957). Pears were found to be the next most popular fruit. Maslansky et al (1974) and Harris and Chan (1969) reported carrots to be the most popular vegetable among infants. They were followed in popularity by sweet potatoes and squash (Harris and Chan,1969). Beal (1957) similarly reported that yellow vegetables were especially liked by one-third of the fifty-seven infants studied. Interestingly, Ferris et al (1978b) reported that carrots, sweet potatoes and squash accounted for forty-nine percent of the sales volume of commercially prepared vegetables for infants in western Massachusetts. Harris and Chan (1969) found that among infants accepting meat, beef and chicken were the favorites. Beal (1957) found liver to be disliked more than any other meat.

It appears evident from this literature that infants less than ten months of age exhibit definite food preferences. Generally, cereal and fruit have been found to be the most accepted food groups by young infants (Ferris et al, 1978b; Guthrie, 1966; Beal, 1957). Vegetables as a group are less popular. More problems have been associated with the introduction of meat to infants than with any other food group. Both Harris and Chan (1969) and Ferris et al (1978b) reported that thirty percent of the infants they surveyed accepted meat poorly or not at all. Because of its sweet taste and high acceptance among infants, fruit has been reportedly mixed with other semi-solids which are not well accepted, such as meat (Ferris et al, 1978b).

B. Oral Development and Implications

The oral-facial region of the human fetus has been reported to respond to tactile stimulation by eight weeks in utero. By approximately twelve weeks gestational age, the face and oral cavity of the fetus are completely innervated (Bradley and Mistretta, 1975). In addition, fetal swallowing of the amniotic fluid has been reported to begin at this time. The amniotic fluid is composed of a wide variety of chemical constituents and contains the fetal excrements (Mistretta and Bradley, 1977). Therefore, the fetus may experience some textural stimulation in utero.

An infant is born with all the muscles, nerves and structures involved in the perception of tactile stimulation. According to Conel (1939, 1941 and 1947), the cerebral cortex of the human infant is immature at birth and for the first month of life. After three months, however, there is accelerated maturation of the sensory receiving areas. This corresponds to the age recommended for introducing semi-solids into an infant's diet (Manitoba Department of Health and Social Development, 1976). Szczesniak (1972) stated that infant foods were soft and smooth in texture. However, sensory evaluation of commercial puréed fruit and vegetable products has revealed texture descriptors including smooth, grainy, pulpy, gritty and chalky (Harasym, 1977).

Before ten months of age, infants are incapable of lateral (side to side) chewing movements. The development of this ability, together with the eruption of the first primary molars, enables an infant to begin to handle and accept solid foods. Before this time, oral function is restricted to handling semi-solids which can be swallowed without requiring mechanical disintegration (Szczesniak, 1972).

There are some indications in the literature that infants less than ten months of age can discriminate texture in semi-solid foods and that it influences their food acceptance. According to Szczesniak (1972), mothers feel that the difficulties some experience in feeding strained meats to their infants is due to its gritty, rough character which appears to make it difficult to control in the mouth. Van Leeuwen et al (1961) reported the results of feeding a variety of frozen infant food to four to twelve month old infants. Some mothers had said that the squash varied in consistency and at times was not accepted by four month old infants. In an infant feeding study conducted by Gonzales et al (1970), beef - and liver - vegetable combinations were fed to five to twelve month old infants. The authors expected the beef - vegetable combinations to be more acceptable to the infants. In anticipation of this finding, the beef - vegetable combinations were fed before the liver - vegetable combinations to coax acceptance of the latter. Surprisingly, the liver - vegetable combinations were significantly preferred. The authors stated that their favorable acceptance was most likely due to the infants' familiarity with the texture of the product, both combinations being similar. The criterion of acceptance used was food consumed as a percentage of the total amount of food served.

II. INFANT TASTE SENSITIVITY

A. Development and Function of Fetal Taste Receptors

Taste buds of adult form are present in the human fetus for the last two-thirds of gestation (Mistretta and Bradley, 1975). A wider distribution of taste buds in the oral cavity of the fetus (and infant) than in the adult has been reported. However, the mean number of taste buds on a circumvallate papillae is relatively constant from birth until twenty years of age. At this time, it declines slightly and remains stable until old age (Bradley and Mistretta, 1975).

The human fetus has been reported to swallow amniotic fluid from about twelve weeks of gestation, the same time as mature taste buds are present (Mistretta and Bradley, 1977). De Snoo (1937) observed increased amounts of amniotic fluid swallowed after injection of saccharin. Liley (1972) found less swallowing after an intra-amniotic injection of a noxious-tasting radio-opaque substance (Lipiodol). This evidence suggests that the human taste system may be functional before birth.

B. Sweet Stimuli

1. Newborns

It has been well established that newborn infants exhibit a sweet preference. Researchers have investigated neonatal reactions to superthreshold concentrations of taste stimuli since before the turn of the twentieth century (Kussmaul, 1859; Preyer, 1882; Peterson and Rainey, 1910; Canestrini, 1913; Pratt et al, 1930). All workers concluded that newborns react positively to sweetness.

More recent studies have confirmed and expanded this finding. It has been repeatedly demonstrated that newborn infants prefer sweet solutions to water (Kobre and Lipsitt, 1972; Desor et al, 1973; Steiner, 1977; Weiffenbach and Thach, 1973; Engen, 1977). Similarly, Nisbett and Gurwitz (1970) found that newborns consumed more of a standard milk formula when the carbohydrates were replaced by sucrose, yielding a 4.7% sucrose solution. The two formulas were nutritionally and calorically equivalent. In addition, newborns' preference for sweetness has been shown to be greater for:

1. higher sugar concentrations over lower ones (Desor et al, 1973; Weiffenbach and Thach, 1973; Crook and Lipsitt, 1976)
2. sweeter sugars, such as fructose and sucrose, over less sweet ones, such as glucose and lactose (Desor et al, 1973; Engen et al, 1974).

In all of these studies, differences between the test fluids were limited to differences in the sugars. The methods used to assess neonate discrimination included observations of facial expressions and body movements, volume of fluid ingested, and differential rates of breathing, suckle or heartbeat.

Studies have been reported where sugar was one, but not the only constituent differentiating the test fluids. Desor et al (1977) offered fifteen neonates a low density milk formula and a 0.3 M sucrose solution. Although the two fluids were equal in caloric density, the infants exhibited significantly greater preferences for the sucrose solution. Within a three minute time period, they consumed over twice the number of calories when the caloric source was the sucrose solution rather than the milk formula.

Both Dubignon and Campbell (1969) and Johnson and Salisbury (1975) obtained differential sucking patterns when newborns were fed either a standard milk formula and five percent dextrose solution or human and cows' milk respectively. These authors reported that differences in the chemical compositions of the fluids and consequent taste was most likely the basis for discrimination. However, differences in viscosity can not be ruled out.

2. Older Infants

The vast majority of work on the taste sensitivity of infants has been conducted on newborns. However, Desor et al (1977) found that infants one to seven months of age also exhibited a preference for sweetness. These infants had been introduced to a variety of non-milk foods and their food intake prior to testing was not controlled. Significantly greater preferences were observed for 0.2 M sugar solutions than for concentrations of 0.1 M. In addition, fructose, which is a sweeter sugar, was ingested in significantly greater quantities than glucose. The sweet preference of infants makes it tempting for mothers to transform a rejected food into an acceptable one by adding sugar.

C. Sour and Bitter Stimuli

It is still uncertain whether newborns can differentiate between sour and bitter stimuli. However, they have been found to be less preferred than sweet stimuli. In 1859, Kussmaul obtained sucking movements in newborns with a saturated sugar solution. "Grimaces of dislike" were reported for quinine sulfate and tartaric acid solutions. Occasionally, the facial response to the sugar was like that to the bitter stimuli. The concentrations tested were not reported. Preyer (1882), Peterson and Rainey (1910), Pratt et al (1930) and, more recently, Steiner (1977) substantiated Kussmaul's findings. All of these investigators reported that newborns' facial expressions were differential for sweet, sour and bitter stimuli, the latter two being adversive.

Steiner (1977) used a 25% sucrose solution for sweet stimulation, a 2.5% citric acid solution for sour and a 0.25% quinine sulfate solution for bitter. Pratt et al (1930) used similar concentrations of these tastants in their investigation.

Canestrini (1913) was the first investigator to use direct measures of cardiovascular and respiratory response for studying neonatal taste reactions. He observed a calming effect on newborns from a two to five percent sucrose solution. Sour and bitter stimulation from a two to five percent vinegar solution and a two percent quinine sulfate solution respectively produced irregularities in breathing action which were not grossly different from each other.

The sour and bitter stimuli concentrations tested by all of these investigators were very high. Adult recognition thresholds for citric acid and quinine sulfate have been reported to be 1.52 $\times 10^{-2}$% and 5.98×10^{-4}% respectively (Pfaffman, 1959). Therefore, the citric acid and quinine sulfate solutions tested by Pratt et al (1930) and Steiner (1977) were of concentrations approximately one-hundred and fifty and four hundred times higher than adult recognition thresholds for these compounds respectively.

Desor et al (1975) measured the volumes of sour and bitter aqueous solutions consumed by one to four day old infants during three minute periods. They were not consumed differentially from water. The highest concentration of citric acid tested (0.048 M) was rated by adults as being quite intense and mildly to moderately unpleasant. In a subsequent experiment, the sour and bitter stimuli were added to a 0.07 M sucrose solution. The concentrations tested ranged from 0.001 M to 0.024 M citric acid and from 0.18 M to 0.48 M urea respectively. There was no effect on the volume of sucrose solution ingested when urea was added. However, the addition of citric acid significantly suppressed the intake of sugar solution. This may have been due to the sweetness of the solution being reduced by the addition of citric acid. The newborns' indifference to the bitter stimuli under both test conditions suggests that they failed to perceive these compounds at the concentrations tested.

The tastant concentrations used by Desor et al (1975) were much more reasonable than those used by other investigators. The highest concentrations of sour and bitter stimuli tested were thirty and four times higher than adult recognition thresholds for these compounds respectively. Adult recognition thresholds of 0.00079 M for citric acid and of 0.12 M for urea have been reported (Pfaffman, 1959). It is conceivable that the adversive reactions to the sour and bitter tastants obtained by the early investigators and Steiner (1977) were due to overstimulation of the trigeminal free nerve endings in the mouth, thus causing pain.

D. Thresholds

Taste thresholds for infants have not been established. However, they have been reported to be much higher than those of adults (Flasarova, 1959). In agreement with Desor et al. (1975), Kulakowskaja (1930) found that adults reacted to weaker citric acid concentrations than did newborns. Neonates responded to a 0.05% quinine solution while adults could frequently perceive bitter in a 0.004% solution. The newborns studied by Kulakowskaja (1930) licked their lips when given a one to two percent sucrose solution. At a sucrose concentration of five percent, a satisfied facial expression appeared and they smacked their tongues against their lips. Using an eyelid conditioned response to taste stimuli, Osepian (1958) reported that infant taste sensitivity increases with growth and development throughout the first year of life. Differentiation of flavored solutions appeared at three months of age.

III. INFANT FEEDING PRACTICES

A. Frequency of Breast-Feeding

Human milk was the primary source of nourishment for infants at the turn of the century. Since then, the frequency of breast-feeding has varied. Bain (1948) found that in 1946, sixty-five percent of infants in the United States were breast-fed or partially breast-fed on discharge from the hospital. This figure decreased to thirty-seven percent by 1956 and to twenty-seven percent by 1966 (Meyer, 1968). The frequency of bottle-feeding rose proportionately.

In the early 1960's, Salber and Feinleib (1966) found that only twenty-two percent of almost three thousand new mothers in Boston attempted breast-feeding, with the mean duration of breast-feeding being three and one-half months. Harris and Chan (1969) found that forty-one percent of three hundred and eighty-three infants were breast-fed for various periods from birth until one month of age. Almost one-half of the mothers breast-feeding did so for over three months.

In 1975, Fomon estimated that only twenty percent of the infants in the United States less than one month of age would be breast-fed. In agreement with this prediction, Maslansky et al (1974) reported that only seventeen percent of their predominantly Black and Peurto Rican sample in New York City was breast-fed at some time.

An increased incidence of breast-feeding is found in the literature in the late 1970's. In 1977, De Swiet et al reported that fifty-six percent of seven hundred and fifty-eight infants in London, England were breast-fed at birth. Cunningham (1977) found that one-half of three hundred and twenty-six infants in New York State were breast-fed on discharge from the hospital.

Cole (1977) surveyed three hundred and thirty-eight expectant mothers in the Boston area and found that fifty-seven percent intended to breast-feed. Of the women who initiated breast-feeding, almost sixty percent were still nursing at three to three and one-half months postpartum.

The situation appears to be similar in Canada. Bramble and Miles (1978) reported that fifty-five percent of one hundred and seven Canadian mothers breast-fed their infants for three months or more. Bergerman et al (1978) surveyed mothers throughout Saskatchewan and found that fifty-eight percent attempted to breast-feed their infants. Similarly, in Manitoba, Clark (1978) reported that fifty-eight percent of four hundred and fifty-six infants were breast-fed at birth. Forty-five percent of four hundred and twenty-one infants were still being nursed at one month of age, thirty-five percent at two months and twenty-eight percent at three months. Tse et al (1978) studied the early feeding patterns of infants in Toronto and Montreal. In Toronto, over seventy percent of the mothers surveyed chose to breast-feed at the time of discharge from the hospital. The percentage in Montreal was slightly lower. The majority of these mothers were still totally or partially breast-feeding three months later.

Contrasting reports are also found in the literature. Ferris et al (1978a) reported that only thirteen percent of two hundred and sixty-eight infants in western Massachusetts were breast-fed. However, over forty percent of the breast-fed infants were nursed for three months or more. Similarly, Mackey and Orr (1978) reported a very low frequency of breast-feeding in Newfoundland. Only seventeen percent of two hundred and twenty-eight infants were breast-fed in the hospital.

There are many factors which influence the decision and ability to breast-feed. Examining the frequency without considering the circumstances can not definitely assess the situation. However, it appears that breast-feeding is currently the favored method of infant feeding in the early weeks of life. The literature indicates that when initiated, the mean duration of breast-feeding is approximately three months.

B. Age of Introduction to Non-Milk Foods

1. Recommendations

Over the years, the age at which infants in North America have been introduced to foods other than milk has varied tremendously. In the 1920's, infants were not given solids until they were nearly a year of age (Hill, 1967). In 1937, the Council on Foods of the American Medical Association suggested that strained fruits and vegetables be introduced to infants at about four to six months of age. By the 1950's, the age recommended for introduction of semi-solids had declined further. The Committee on Nutrition of the American Academy of Pediatrics (1958) concluded that no nutritional or psychological benefits were to be gained by introducing semi-solids at ages earlier than two and one-half to three months. The Committee agreed with those objecting to the use of age as a rigid standard governing the time of solids introduction.

Anderson (1977) and Pipes (1977) suggest that developmental readiness rather than chronological age is the important criterion in determining the age of introducing semi-solids. According to these authors, infants are ready for semi-solids between the developmental ages of four and six months. They are able to sit with support, have head and neck control and have developed a more mature sucking pattern. Pipes (1977) stated that no nutritional or developmental advantage will be derived from introducing semi-solids prior to this time. In addition, this author contended that it is important for infants to have the sensory stimulation from semi-solids and experiences which desensitize the gag reflex by the developmental age of six months.

The Manitoba Department of Health and Social Development (1976) recommends the introduction of cereal at three months, vegetables at three and one-half, fruit at four and meat at five months. They suggest the introduction of vegetables before fruit since "infants often prefer the sweetness of fruit and may not accept vegetables if the order is reversed."

2. Practices

According to Anderson (1977), most mothers who breast-feed their infants are less anxious to introduce semi-solids. An earlier age of semi-solid introduction has been associated with an increased incidence of bottle-feeding.

Neumann and Alpaugh (1976), Cole (1977) and Bramble and Miles (1978) found that bottle-fed infants were started on solids significantly earlier than breast-fed infants. Semi-solids were introduced at mean ages of 1.9 months and 3.9 months respectively (Neumann and Alpaugh, 1976). Ounsted and Sleigh (1975) found that at two months of age, significantly more bottle - than breast-fed infants were receiving solids, seventy-eight percent versus forty-four percent respectively. Similarly, De Swiet et al (1977) reported that by the age of six weeks, additional semi-solids were given to twenty-two percent of bottle-fed infants but only to four percent of those breast-fed. However, Ferris et al (1978b) and Beal (1969) reported that semi-solids were introduced at an early age in both breast - and formula fed infants.

Contrary to the recommendation of the Manitoba Department of Health and Social Development (1976), semi-solids are usually introduced in the order of cereal, fruit, vegetables and meat (Harris and Chan, 1969; Maslansky et al, 1974; Beal, 1957; Ferris et al, 1978b). Beal (1957) followed fifty-seven children at regular intervals from birth between 1946 and 1957. Over the ten year period, striking differences were noted in the ages at which foods other than milk were started. In 1946, cereal was not introduced until almost two and one-half months of age, fruits and vegetables between four and five months, and meat at eight months. By 1955, both cereal and fruit were started at one month, vegetables at about two and one-half months and meat at four and one-half months.

Numerous investigators have reported a frequent introduction of semi-solids to infants prior to the recommended age of three months (Manitoba Department of Health and Social Development, 1976). Rice cereal is commonly the first food to be added to an infant's diet (Ferris et al, 1978b; Pipes, 1977; Harris and Chan, 1969; Salber and Feinleib, 1966). Harris and Chan (1969) reported that eighty percent of three hundred and eighty-three infants received cereal at or before one month of age and fifty-two percent had been started on fruit. Mackey and Orr (1978) and Maslansky et al (1974) found that over forty percent of four hundred and fifty-one and two hundred and twenty-eight infants respectively were introduced to some type of semi-solid in the first month of life. Beal (1969) reported that the majority of ninety-five infants received solids by one month of age. Ferris et al (1978b) surveyed the feeding patterns of two hundred and sixty-eight infants less than six months of age in western Massachusetts. Of the infants less than one month of age, fifty-seven percent were given cereal, thirty-two percent fruit and four percent vegetables, as a regular part of their diets.

By two months of age, almost three-quarters of one hundred and ninety-one infants studied by Ounsted and Sleigh (1975) were introduced to semi-solids. Guthrie (1966) investigated fifty infants and found that they all had started on solids by approximately two months of age. Similarly, ninety-two percent of Mackey and Orr's (1978) sample received solids before two months. Of the infants surveyed by Ferris et al (1978b) between one and two months of age, eighty-seven percent were receiving cereal, eighty-one percent fruit, thirty-one percent vegetables and three percent meat. By three months, approximately twice as many infants were taking vegetables and almost twenty-five percent were started on meat.

It appears that semi-solids are being introduced to infants at an earlier age than is recommended. This practice may be related to an increased incidence of bottle-feeding or early age of weaning from the breast.

IV. SENSORY EVALUATION OF TEXTURE

Sherman (1970) defined food texture as "the composite of those properties which arise from the structural elements (of a food) and the manner in which it registers with the physiological senses." This definition recognizes three essential elements of texture:

1. That it is a sensory quality.
2. That the texture of any food is directly related to its underlying structure or inner make-up.
3. That it is a complex phenomenom composed of several properties (Szczesniak, 1977).

To date, sensory evaluation is probably the only reliable way to completely characterize the texture of a food. Texture is perceived in the mouth through two sets of sense organs:

1. Those in the tongue, gums and hard and soft palate - the tactile or feel sense.
2. Those around the roots of the teeth and in the muscles and tendons used in mastication - the kinesthetic sense (Amerine et al, 1965).

In recent years, increased attention has been focused on attempting to correlate sensory and instrumental texture measurements since the latter are more efficient and reproducible (Moskowitz, 1977; Kapsalis and Moskowitz, 1977). Sensory assessment of texture is clearly more meaningful, however. No one instrumental reading can fully characterize the texture of a food and the proper mechanical test(s) will vary according to the type of food. The maximum correlation obtainable by instrumental and sensory methods will always be limited since no machine can simulate the human sensor.

In 1963, Szczesniak developed the classical classification of textural characteristics and standardized the nomenclature used for food texture evaluation. Textural characteristics were grouped into three main classes: mechanical characteristics, geometrical characteristics and characteristics concerned with the lubricating and mouthcoating properties of a product. Standard rating scales reported to cover the entire intensity ranges of these characteristics found in foods were developed by Szczesniak et al (1963). All points on the scales were illustrated by selected food products. The Texture Profile Method (Brandt et al, 1963) is based on Szczesniak's classification system and utilizes a category scale to quantitate the textural characteristics of a food product. Modifications of this method have recently been published (Civille and Liska, 1975).

A. Limitations of Scaling

Several limitations have been associated with the use of category scales (Stevens and Galanter, 1957). They are based on the assumption that the psychological intervals between all scale points are equal and this is not necessarily true. Also, the category scale lacks a true zero. Differences in ratings provide information about intervals but ratios of differences cannot be obtained. Finally, judges tend to avoid using the extreme endpoints of the scale resulting in judgement biases (Moskowitz and Sidel, 1971). Cloninger et al (1976) found that this "central tendency" increased as the number of categories increased. Categories were more evenly spaced with a five-point scale than for nine- and fifteen-point scales.

B. Magnitude Estimation

The method of magnitude estimation has become an increasingly popular alternative for quantifying sensory experience. This technique eliminates many of the biases associated with category scaling and provides a sounder form of measurement (Kapsalis and Moskowitz, 1977). Panelists are instructed to freely assign numbers to stimuli in proportion to the perceived intensity of their sensations. A ratio scale of magnitude is thus created.

Only the ratios between a panelist's numbers convey information regardless of their size and range (Moskowitz and Sidel, 1971). Magnitude estimation has been found to be simple to use and give reproducible results (Moskowitz et al, 1972). Furthermore, data on two related yet discriminable sensations produced by the same physical stimulus can be successfully obtained (Hawkes, 1960).

Numerical judgements of sensory magnitude can be correlated with physical intensity measurements using the power function $S=kC^n$. In this way, sensory response (S) can be predicted for a given physical intensity (C) of a sensation. The values of k and n are constants and the exponent n reflects how sensory magnitude grows with increasing physical intensity. When n equals 1.0, then the relationship between sensory and physical intensity is linear and both grow at the same rate. If n is greater than 1.0, perceived intensity grows more rapidly than physical intensity. Conversely, when n is less than 1.0, sensory magnitude grows more slowly than physical intensity (Moskowitz et al, 1972).

Beginning with Stevens (1969), numerous investigators have defined such psychophysical functions for a variety of taste sensations using direct magnitude estimation. Psychophysical measures of textural characteristics have also been reported (Moskowitz et al, 1972; Kapsalis and Moskowitz, 1977).

METHODS AND MATERIALS

To aid the reader, a summary of the overall objectives of each section of the methodology is outlined in Table 1.

I DETERMINATION OF TASTE AND TEXTURAL CHARACTERISTICS IN HEINZ INFANT FOODS

The only puréed infant foods marketed in Winnipeg are supplied by H. J. Heinz Company[1]. In preliminary work, Heinz products were assessed by untrained but experienced sensory panels to determine their taste and textural characteristics. Six to eight students and staff members from the Department of Foods and Nutrition, University of Manitoba, served as judges. The textural characteristics of Heinz fruit, dessert and vegetable products and selected meat and cereal products were assessed using descriptive analysis. The panel rated the degrees of sweetness and sourness in Heinz fruit, dessert and vegetable products, as well as the degree of bitterness in the latter, on nine-point category scales.

Heinz strained infant foods possessed a wide range of taste and textural characteristics. Some Junior products were also evaluated. Both the strained and Junior product possessed the same textural characteristics but they were more pronounced in the latter.

1. H. J. Heinz Company of Canada Limited, Leamington, Ontario.

Table 1

Overall Objectives of the Methodology by Section

Section of Methodology		Overall Objective
I	1.	To determine the taste and textural characteristics of Heinz infant foods using an experienced sensory panel.
	2.	To select combinations of textural characteristics encountered in Heinz infant foods for study.
II A.	3.	To develop base systems to copy these textural characteristics and combine them to form six textural systems for study.
B.	4.	To train an adult sensory panel to evaluate the taste and textural characteristics found in purêed food systems.
C.	5.	To develop the texture systems to represent the textural intensities found in Heinz infant foods using a trained sensory panel.
	6.	To determine the concentrations of basic tastants which represent the maximum perceived intensities of sweetness, sourness and bitterness found in Heinz infant foods using a trained sensory panel.
	7.	To create a sweet, sour and bitter system for study by adding these taste intensities to a texture base.
III and IV	8.	To define the sensory characteristics of the model systems using a trained sensory panel.
V	9.	To determine infant acceptance of the model systems.

The textural characteristics of the combination fruit, vegetable and meat products were generally a composite of those found in their constituent single products.

Six combinations of textural characteristics present in Heinz infant foods were reproduced in model systems for study. These were chosen by the experimenter:

1. Smooth - Thick
2. Smooth - Thin
3. Pulpy
4. Gritty - Grainy
5. Chalky - Drying
6. Grainy - Gummy - Mouthcoating.

The six model systems were selected for the following reasons. The Heinz products ranged in viscosity from very thick to runny. Smoothness, pulpyness and gritty - graininess were present in many Heinz fruit, dessert and vegetable products. These textures were isolated into four treatments for study. A smooth - thick system was to represent products such as Heinz strained banana, mixed fruit, and dessert items. A smooth - thin treatment was to represent the less viscous Heinz products such as strained carrots, peas and creamed corn. Gritty - graininess was present in Heinz strained pears and prunes. This texture was illustrated by a gritty - grainy treatment. A pulpy treatment illustrated the pulpyness found in Heinz strained carrots, green beans and applesauce.

Strained peas and peas and carrots were very chalky and drying. Peas are a commonly served vegetable and vegetables are often the least accepted food group by infants and children. Therefore, this unique textural system was reproduced for study.

A grainy - gummy - mouthcoating treatment simulated the texture of commercial strained meat products. This texture was chosen for study since Szczesniak (1972) reported that some infants may not accept strained meats well due to their gritty, rough character. Strained meats are also dry.

II DEVELOPMENT AND SENSORY EVALUATION OF MODEL SYSTEMS

A. Preparation of Texture Bases

The six textural systems of interest were reproduced in model systems using Berryland Farm brand Applesauce and Bartlett Pears and Aylmer brand Whole White Potatoes. The latter were purchased from the same case lot number to protect against inherent harvesting and processing variables. Due to the quantity involved, the applesauce was purchased from two case lots and mixed. Product specifications are given in Appendix A.

Applesauce was chosen as the base for the texture systems by the experimenter. This product is pulpy yet can be made smooth by puréeing. Pears and potatoes, puréed to varying degrees and freeze-dried, were used to produce different particle sizes and shapes in the gritty - grainy and chalky - drying, grainy - gummy - mouthcoating treatments respectively. The potatoes also imparted the characteristic of dryness.

Preliminary processing of the products into basic ingredients for the systems took place in the Department of Food Science, University of Manitoba, between the months of November, 1977 and February, 1978. Smooth and pulpy applesauce bases, puréed pears and potatoes and liquified potatoes were prepared following the procedures outlined in Appendix B.

1. Sterilization of Equipment

All equipment was sterilized before and after each preparation. The muslin and all metal, glass and hard plastic equipment used were sterilized by autoclaving at 120°C for thirty minutes. Soft plastic and heat sensitive equipment were sterilized using a 200 ppm chlorine solution[2]. Objects sterilized in this manner were rinsed with tap water to remove any residual chlorine. Prior to opening each can of product, the tops of the cans and the opener were sterilized with the chlorine solution.

2. 20 ml Divex (12% Na Hypochlorite) per litre H2O.

The final model system samples (Section II C 4) were prepared in the Foods and Nutrition Laboratory, Faculty of Home Economics, University of Manitoba, in February, 1978. All equipment was sterilized using a 200 ppm chlorine solution. The counter tops, walls and sinks directly in the processing areas were washed down before and after each preparation with a 200 ppm chlorine solution. The processor's hands were sterilized by continuously dipping them in the chlorine solution. All water used directly in the preliminary or final processing operation was sterilized by boiling for a minimum of fifteen minutes at 100°C. Surgical masks were worn throughout the preparation periods. The sterilization techniques were approved by the Food Microbiology Specialist in the Department of Food Science, Faculty of Agriculture, University of Manitoba, as adequate to ensure the microbiological safety of the final samples.

2. Percent Moisture Analyses

Moisture determinations were conducted to determine the percent solids concentrations of the applesauce bases and the processed pears and potatoes (Appendix B). Percent moisture is calculated by weighing a sample before and after freeze-drying and using the formula:

$$\%\ \text{Moisture} = \frac{\text{Sample weight (g) Before Drying} - \text{Sample weight (g) After Drying}}{\text{Sample Weight (g) Before Drying}} \times 100\%$$

Percent solids can then be determined using the formula:

% Solids = 100% - % Moisture.

The mean values found in Appendix C represent the percent moisture and solids contents of the basic ingredients used to prepare the final samples.

B. Selection and Training of Panelists

The final formulations for the model systems were determined using a trained adult sensory panel.

1. Selection of Panelists

Eight female students from the Faculty of Home Economics, University of Manitoba, were screened for their ability to identify weak solutions of basic taste sensations. All were found to have at least average taste acuity. However, one student was uninterested in the project and not asked to participate.

2. Training of Panelists

i) Purpose, Duration and Environment

The seven selected panelists were trained to identify and quantitate the textural characteristics and the basic taste sensations found in purēed infant foods. A total of ten one-hour training sessions were held over a three month period. Sessions were held around a large table to facilitate group discussion.

ii) Sensory Evaluation Technique

Magnitude estimation, a form of ratio scaling, was used as the measuring instrument throughout the training sessions and for all of the sensory evaluation conducted in this study. The intensity of a sensory characteristic in a sample was rated against that found in a reference standard illustrating the characteristic. For example, when evaluating sourness, panelists were given a reference citric acid solution to which they assigned a score of ten. If the sourness perceived in a sample were half that perceived in the reference, it was given a score of five. If a sample were found to be twice as sour, it received a score of twenty. If a characteristic were not perceived in a sample, panelists were instructed to use "NP" for not present. Reference standards were always assigned scores of ten. All panelists were familiar with magnitude estimation and did not have to be trained in its use.

iii) Training in Texture Evaluation

In the first of seven sessions, panelists were presented with a list of definitions and a set of reference standards for seven textural characteristics. The experimenter believed that these characteristics encompassed the range of those found in Heinz infant foods and the model systems. Panelists read the definitions, tasted the reference standards and tried to relate the definition to the handling and/or feel of the reference in the mouth. Modifications in the definitions were made and more appropriate references were suggested.

In succeeding sessions, selected Heinz strained fruit and vegetable products were evaluated. This further familiarized panelists with the method of magnitude estimation and revealed inconsistencies between their judgements. Following each session, the group discussed the results and the definitions and reference standards were revised where necessary. Individual panelists scores were examined for inconsistencies. At the end of the training period, magnitude estimates were consistent both within and between panelists. The final set of texture definitions and reference standards are found in Figure 1. Panelists felt that the range of textural characteristics found in purèed food systems could be defined using the seven characteristics shown.

iv) Training in Taste Evaluation and Final Session

Panelists were given various concentrations of sweet, sour and bitter solutions and descriptions of these sensations. They selected the concentrations with which they all felt comfortable for use as reference standards (Table 2). The panel then scaled the taste intensities in selected Heinz strained fruit and vegetable

Figure 1

Texture Definitions and Reference Standards

Viscosity - the force required to suck the sample between the tongue and the palate. Reference: Diluted sweetened condensed milk.

Particle Size - the presence of distinct, regularly shaped particles in the sample which increase in size from chalky to gritty to grainy. Smooth = "NP" for this parameter - absence of distinct particles. Reference: Puréed pears.

Amount of Particles - the number of distinct, regularly shaped particles in the sample. Reference: Puréed pears.

Pulpyness - the amount of distinct, irregularly shaped (soft) particles in the sample. Reference: Puréed carrots.

Gumminess - the tendency of a sample to remain intact - evaluate by rolling the sample between the tongue and the roof of the mouth. Reference: Flour paste.

Dryness - sample produces the sensation of removing moisture from the mouth - the extent to which sample removes moisture from the mouth. Reference: Puréed potato.

Mouthcoating - a film of sample which remains on (clings to) the tongue and/or palate following swallowing or expectoration. Reference: Puréed corn.

products against their respective references. The ballot used is found in Appendix D. Taste intensity judgements were consistent both within and between panelists at the end of the two training sessions.

Prior to the primary sensory evaluation conducted in this investigation (Section III), a final session was held. Panelists assessed the taste and textural characteristics of two of the model system samples used in the study. Results indicated that all panelists were perceiving in the same direction.

C. Development of Model Systems

1. Sensory Testing Procedure

i) Environment

Panels were conducted in the late morning or early afternoon. All samples were evaluated in humidity controlled, relatively sound proof sensory booths in the Foods and Nutrition Laboratory, Faculty of Home Economics, University of Manitoba. Red lights were used to mask any color differences.

ii) Serving of Samples and Instructions

All samples were served in 40 ml No. 17 treated Lily creamers, covered with lids and coded with three digit random numbers. The Heinz strained meat and vegetable products were placed in 55°C water baths on warming trays. All other samples were served at room temperature. Tap distilled water and unsalted soda crackers were provided for rinsing. Panelists were instructed to rinse with a cracker between any mouthcoating and bitterness evaluations to eliminate possible carryover effects. They were instructed to swallow when evaluating bitterness.

Since the sensory data were to be related to differences found in infant acceptability, panelists were instructed to handle the samples as an infant would. Samples were to be assessed using in and out movements of the tongue only, with the food generally between the tongue and palate.

iii) Preparation of Reference Standards

The methods and products used to prepare the reference standards are given in Table 2. On each day of testing, standards were placed in sample cups, covered with lids and labelled appropriately. They were presented to panelists at room temperature.

2. <u>Texture Systems</u>

The model systems were developed to represent the textural intensities found in Heinz strained infant foods. For each model system, the testing procedure was as follows:

Panelists were presented with:

1. A formulation of the model system

Table 2

Products and Procedures Used in the Preparation of Reference Standards

Standard	Product	Product Source	Preparation Procedure
Sweet	Sucrose	Fine granulated sugar, Manitoba Sugar Co., Winnipeg, Manitoba.	A 2.00% sucrose solution (weight by volume in tap distilled water) was prepared on each day of testing.
Sour	Citric Acid	Reagent, A.C.S Powder, Matheson Coleman & Bell Norwood (Cincinnati), Ohio; East Rutherford, New Jersey.	A 0.02% citric acid solution (weight by volume in tap distilled water) was prepared on each day of testing.
Bitter	Caffeine	J.T. Baker Chemical Co. Phillipsburg, New Jersey.	A 0.05% caffeine solution (weight by volume in tap distilled water) was prepared on each day of testing.
Viscosity	Sweetened Condensed Milk	Eagle Brand Sweetened Condensed Milk. The Borden Co. Ltd., Toronto, Canada.	Each week of testing, a can was opened, blended with 10 ml of tap water and stored in an air tight container in the refrigerator.

Table 2 cont'd.

Standard	Product	Product Source	Preparation Procedure
Particle Size Amount of Particles	Canned Pears	Enchanted Isle brand Bartlett Pears Empress Foods Ltd., Vancouver, B.C.	Each week of testing, a can was opened, drained and blended intermittently for 60 seconds in a Viking Kitchen blender on purée. Once blended, the puréed pears were stored in an air tight container in the refrigerator.
Pulpyness	Canned Carrots	Morden Manor brand Short and Sweet Carrots Morden Fine Foods Ltd., Morden, Manitoba.	Each week of testing, a can was opened, drained and blended intermittently for 30 seconds in a Viking Kitchen blender on purée. Once blended, the puréed carrots were stored in an air tight container in the refrigerator.
Gumminess	Flour Paste	Robin Hood All Purpose Flour Robin Hood Multifoods Ltd., Montreal, Canada.	Each day of testing, a 40% (weight by volume) flour paste was prepared. 40 grams flour, f.g. salt were blended with 60 ml tap water.

Table 2 cont'd

Standard	Product	Product Source	Preparation Procedure
Dryness	Canned Potato	Aylmer brand Whole White Potatoes Canadian Canners Ltd., Hamilton, Ontario.	Each week of testing, a can was opened, drained and blended with 100 ml tap water for 60 seconds in a Viking Kitchen blender on purée. Once blended, the puréed potatoes were stored in an air tight container in the refrigerator.
Mouth-coating	Frozen Corn	Green Giant Niblets Whole Kernel Corn Green Giant of Canada Ltd., Windsor Ontario.	Each week of testing, 1/2 pound (227 grams) of corn was boiled in enough tap water to cover for 20 minutes, drained and blended in a Viking Kitchen blender on purée for 2 minutes. The puréed corn was strained and stored in an air tight container in the refrigerator.

2. Definitions (Figure 1) and reference standards (Table 2) for the textural characteristics pertaining to that system

3. Samples of Heinz strained products which represented high and low extremes of the characteristics contained in the system.

Panelists then scaled the intensities of the characteristics in the model system and commercial samples against the references. For example, the smooth - thick formulation and its two commercial extremes were only assessed for viscosity, particle size and amount of particles. Only the viscosity of the system, in relation to that of the commercial samples, and the absence of distinct particles were of interest in determining the final formulation for this treatment. The formulations were varied until the panel's magnitude estimates for the model systems fell between those for their commercial extremes or as close to them as physically possible (Table 3).

The texture treatments were designed to be as bland as physically possible. In preparing the basic ingredients for the systems (Appendix B), all products were washed with hot water to remove as much of their natural flavor as possible. However, the texture formulations possessed some sourness. The sour notes in the systems were masked by small additions of sucrose. The sucrose levels used (Table 5) were selected by three experienced judges from the Department of Foods and Nutrition, University of Manitoba, and they did not add obvious sweetness to the treatments.

Table 3

Panel Magnitude Estimates* of Selected Textural Characteristics in Final Texture System Formulations and Selected H. J. Heinz Company Strained Products

A. Smooth-Thick Treatment

Characteristic / Sample / Judge	Viscosity			Particle Size			Amount of Particles		
	Corn	Bananas	Smooth-Thick Treatment	Corn	Bananas	Smooth-Thick Treatment	Corn	Bananas	Smooth-Thick Treatment
1	3	9	6	NP	NP	NP	NP	NP	NP
2	4	9	5	NP	NP	NP	NP	NP	NP
3	6	8	7	NP	NP	NP	NP	NP	NP
4	1	5	2	NP	NP	NP	NP	NP	NP
5	1	5	2	NP	NP	NP	NP	NP	NP
6	5	15	10	NP	NP	NP	NP	NP	NP
7	5	15	3	NP	NP	NP	NP	NP	NP

*Reference = 10

Table 3 cont'd

B. Smooth-Thin Treatment

Characteristic / Sample / Judge	Viscosity			Particle Size			Amount of Particles		
	Carrots	Corn	Smooth-Thin Treatment	Carrots	Corn	Smooth-Thin Treatment	Carrots	Corn	Smooth-Thin Treatment
1	1.5	4	3	2	NP	NP	4	NP	NP
2	3	5	5	NP	NP	NP	NP	NP	NP
3	5	8	6	NP	NP	NP	NP	NP	NP
4	1	3	2	NP	NP	1	NP	NP	30
5	2	4	2	NP	NP	NP	NP	NP	NP
6	0.1	5	0.01	8	NP	NP	0.01	NP	NP
7	5	7	5	5	NP	6.5	100	NP	1000

Table 3 cont'd

C. Pulpy Treatment

Characteristic / Sample / Judge	Viscosity			Pulpyness		
	Applesauce	Carrots	Pulpy Treatment	Applesauce	Carrots	Pulpy Treatment
1	3	1	3	1	13	11
2	5	4	4	NP	8	8
3	4	3	4	2	6	7
4	3	1	0.5	3	13	11
5	8	5	6	NP	12	8
6	2	1	1	NP	13	1
7	4	1	3	NP	15	8

Table 3 cont'd

D. Gritty-Grainy Treatment

Characteristic / Sample / Judge	Viscosity			Particle Size			Amount of Particles		
	Pears	Prunes	Gritty-Grainy Treatment	Pears	Prunes	Gritty-Grainy Treatment	Pears	Prunes	Gritty-Grainy Treatment
1	3.5	5	4	NP	1	2.5	NP	2	4.5
2	5.5	9	8	NP	NP	NP	NP	NP	NP
3	7	8.5	6.5	4	NP	6	25	NP	5
4	7.5	8	6	3	3.5	2	18	12	15
5	3	5	1.5	2	NP	NP	10	NP	NP
6	15	10	7	NP	NP	0.01	NP	NP	80
7	8	15	15	NP	NP	5	NP	NP	100

Table 3 cont'd

E. Chalky - Drying Treatment

Characteristic / Sample / Judge	Viscosity			Particle Size		
	Garden Vegetables	Peas	Chalky-Drying Treatment	Garden Vegetables	Peas	Chalky-Drying Treatment
1	4	0.5	1.5	1	0.5	2
2	6	1.5	5	NP	0.01	8
3	8	7.5	5	1	2	8
4	5	0.5	2	1	2	5
5	3.5	3.5	3	NP	1	2.5
6	5	0.05	0.1	0.01	NP	8
7	8	5	6	5	5	10

Table 3 cont'd

E. Chalky - Drying Treatment cont'd

Characteristic / Sample / Judge	Amount of Particles			Dryness		
	Garden Vegetables	Peas	Chalky-Drying Treatment	Garden Vegetables	Peas	Chalky-Drying Treatment
1	4	40	20	1.5	11	3
2	NP	100	11	6	8	4
3	70	50	20	3	7.5	6
4	15	40	30	3	6	4.5
5	NP	50	100	2	2	3
6	40	NP	12	8	6	NP
7	200	100	7.5	6	4	7

Table 3 cont'd

F. Grainy - Gummy - Mouthcoating Treatment

Characteristic / Sample / Judge	Viscosity			Particle Size			Amount of Particles		
	Chicken with Broth	Beef with Broth	Grainy-Gummy-Mouthcoating Treatment	Chicken with Broth	Beef with Broth	Grainy-Gummy-Mouthcoating Treatment	Chicken with Broth	Beef with Broth	Grainy-Gummy-Mouthcoating Treatment
1	2.5	7	3	4	8	13	12	9	15
2	8	8	6	NP	NP	0.5	NP	NP	15
3	8	9	9	3	1.5	15	60	60	20
4	4	6	4.5	15	18	13.5	18	20	13
5	6	9	7	1	1	3	100	50	1000
6	15	30	2	6	1	20	1	5	50
7	7	9	5	NP	NP	10	NP	NP	20

Table 3 cont'd

F. Grainy - Gummy - Mouthcoating Treatment cont'd

Characteristic	Gumminess			Mouthcoating		
Sample / Judge	Chicken with Broth	Beef with Broth	Grainy-Gummy-Mouthcoating Treatment	Chicken with Broth	Beef with Broth	Grainy-Gummy-Mouthcoating Treatment
1	4	8	5	5	7	3
2	5	6	3	5	7	NP
3	1	2	NP	8	7	15
4	2	2	5	1.5	2	3.5
5	15	20	9	5	1	2
6	0.01	0.1	1	NP	NP	0.1
7	3	4	3	5	2	3

3. Taste Systems

The concentrations of sucrose, citric acid and caffeine which corresponded to the maximum perceived intensities of sweetness, sourness and bitterness found in Heinz strained infant foods were determined from power functions of these tastants. These taste intensities were added to the smooth - thin texture treatment resulting in a sweet, sour and bitter system for study. Saltiness was not investigated due to the danger of infant hypertonicity and the current trend of eliminating salt in the manufacture of commercial baby food.

i) Power Function Determinations

Power functions of sweetness, sourness and bitterness were determined in two media:

1. tap distilled water (percent weight by volume)
2. the smooth - thin texture treatment (percent weight by weight).

Increasing concentrations of sucrose, citric acid and caffeine were added to both media. The sweet and sour stimuli were added to an unsweetened smooth - thin formulation. The bitter stimuli were added to a formulation containing 1.5% sucrose (w/w) to mask the initial sourness in this treatment. The testing procedure was as follows:

Panelists were presented with:

1. A series of taste stimuli

2. Sweet, sour or bitter reference solutions (Table 2)

3. Heinz strained infant foods representative of the maximum perceived intensities of sweetness, sourness and bitterness found in these products (established in Section I)

4. A ballot (Appendix E).

Panelists were instructed to rate the taste intensities of the samples against that of the reference.

The stimuli concentrations used and Heinz strained products assessed are presented in Table 4. Samples were presented to panelists in random order except for the two highest stimuli concentrations. These were evaluated last to avoid fatigue.

ii) Analyses of Data

Results indicated that one panelist was not using the method of magnitude estimation correctly. Therefore, her results were not included in the analyses and her participation on the panel was discontinued.

The data were normalized (Section IV A) and linear regression analysis was applied. High frequencies of "NP" judgements were given at the lowest concentrations of the sweet and bitter stimuli tested indicating that the panel was not perceiving. Therefore, these concentrations were not included in the analyses. A numerical value was substituted for "NP" judgements at concentrations included in the analyses. These values were obtained by averaging the numerical judgements given for that stimulus concentration.

Table 4

Percent Stimuli Concentrations* and H. J. Heinz Company Strained Products Assessed in Power Function Determinations

Basic Taste	Stimulus	% Concentrations	Heinz Strained Product
Sweet	Sucrose	0.500	Pineapple and Pears
		1.000	
		2.000	
		4.000	
		8.000	
		16.000	
Sour	Citric Acid	0.010	Apple Raspberry
		0.025	
		0.050	
		0.100	
		0.200	
		0.400	
Bitter	Caffeine	0.010	Peas
		0.025	
		0.050	
		0.100	
		0.200	
		0.400	

* weight by volume in tap distilled water; weight by weight in smooth - thin texture treatment

The concentrations of sucrose, citric acid and caffeine representing the maximum perceived intensities of sweetness, sourness and bitterness in Heinz strained infant foods were obtained from the power functions in both media. This is graphically illustrated in Figures 2, 3 and 4. For example, Heinz Strained Pineapple and Pears represented the maximum perceived intensity of sweetness found in this infant food. The panel's sweetness intensity estimate for this product was placed on the sweetness power functions found in Figure 2. It was found that Strained Pineapple and Pears were equivalent in perceived sweetness intensity to a 7.5% (w/v) sucrose solution and a sucrose concentration of 10.0% (w/w) in the smooth - thin texture treatment. Therefore, the latter sucrose concentration was added to the smooth - thin texture treatment, creating a sweet treatment for study.

4. Preparation of Final Samples

Table 5 contains the formulations used to prepare the nine model systems for study. The applesauce bases were removed from the freezer and thawed under refrigeration. Approximately five thousand grams of each treatment were prepared. The grainy - gummy - mouthcoating and chalky - drying treatments were forced through a metal kitchen strainer (36 divisions/cm^2) to distribute the particles uniformly.

Figure 2

SWEETNESS POWER FUNCTIONS AS DETERMINED IN TAP DISTILLED WATER AND SMOOTH - THIN TEXTURE TREATMENT BY TRAINED SENSORY PANEL AND SWEETNESS PERCEIVED IN HEINZ PINEAPPLE AND PEARS EXPRESSED AS CONCENTRATIONS OF SUCROSE

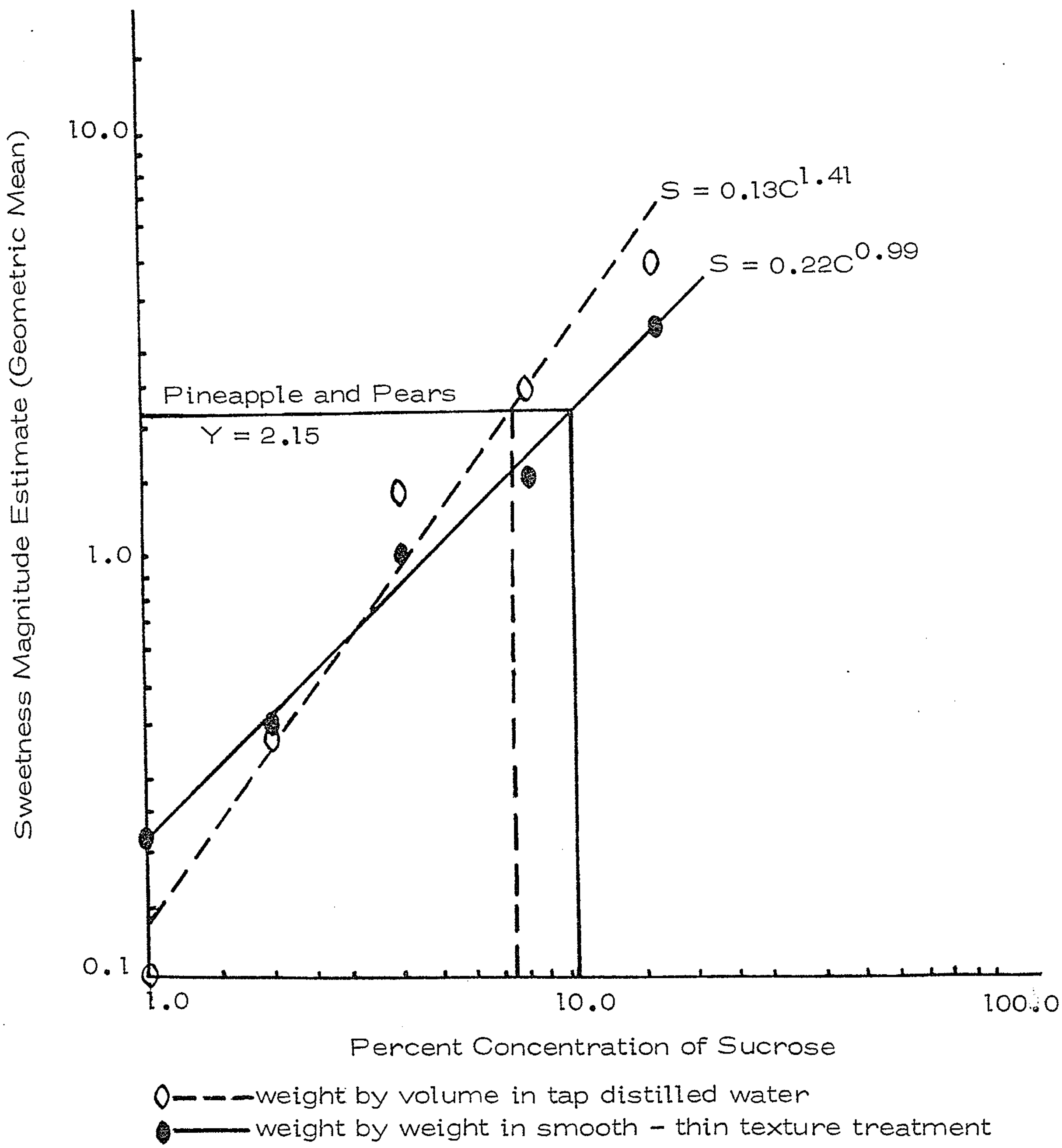


Figure 3

SOURNESS POWER FUNCTIONS AS DETERMINED IN TAP DISTILLED WATER AND SMOOTH - THIN TEXTURE TREATMENT BY TRAINED SENSORY PANEL AND SOURNESS PERCEIVED IN HEINZ APPLE RASPBERRY EXPRESSED AS CONCENTRATIONS OF CITRIC ACID.

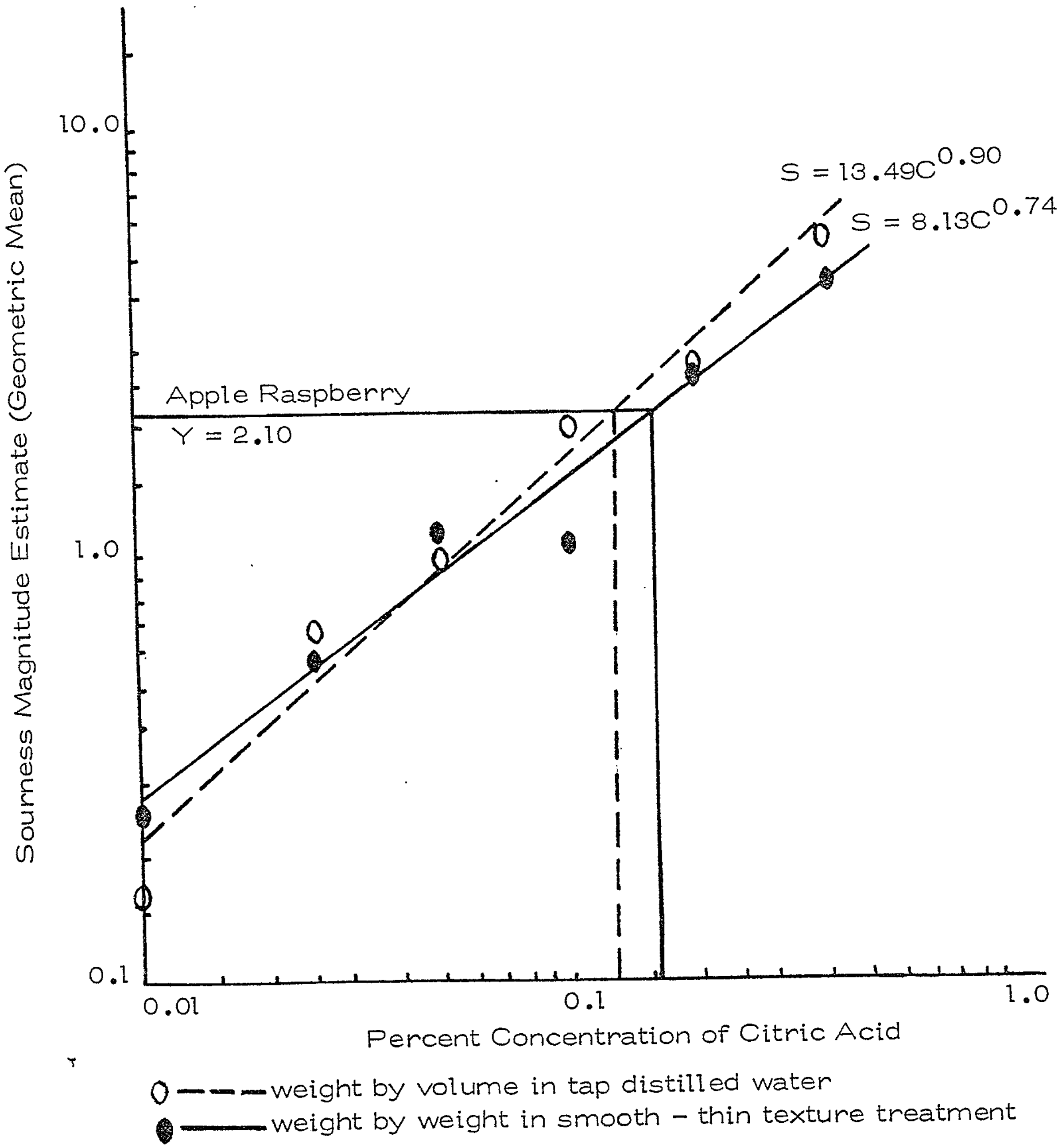


Figure 4

BITTERNESS POWER FUNCTIONS AS DETERMINED IN TAP DISTILLED WATER AND SMOOTH - THIN TEXTURE TREATMENT BY TRAINED SENSORY PANEL AND BITTERNESS PERCEIVED IN HEINZ PEAS EXPRESSED AS CONCENTRATIONS OF CAFFEINE.

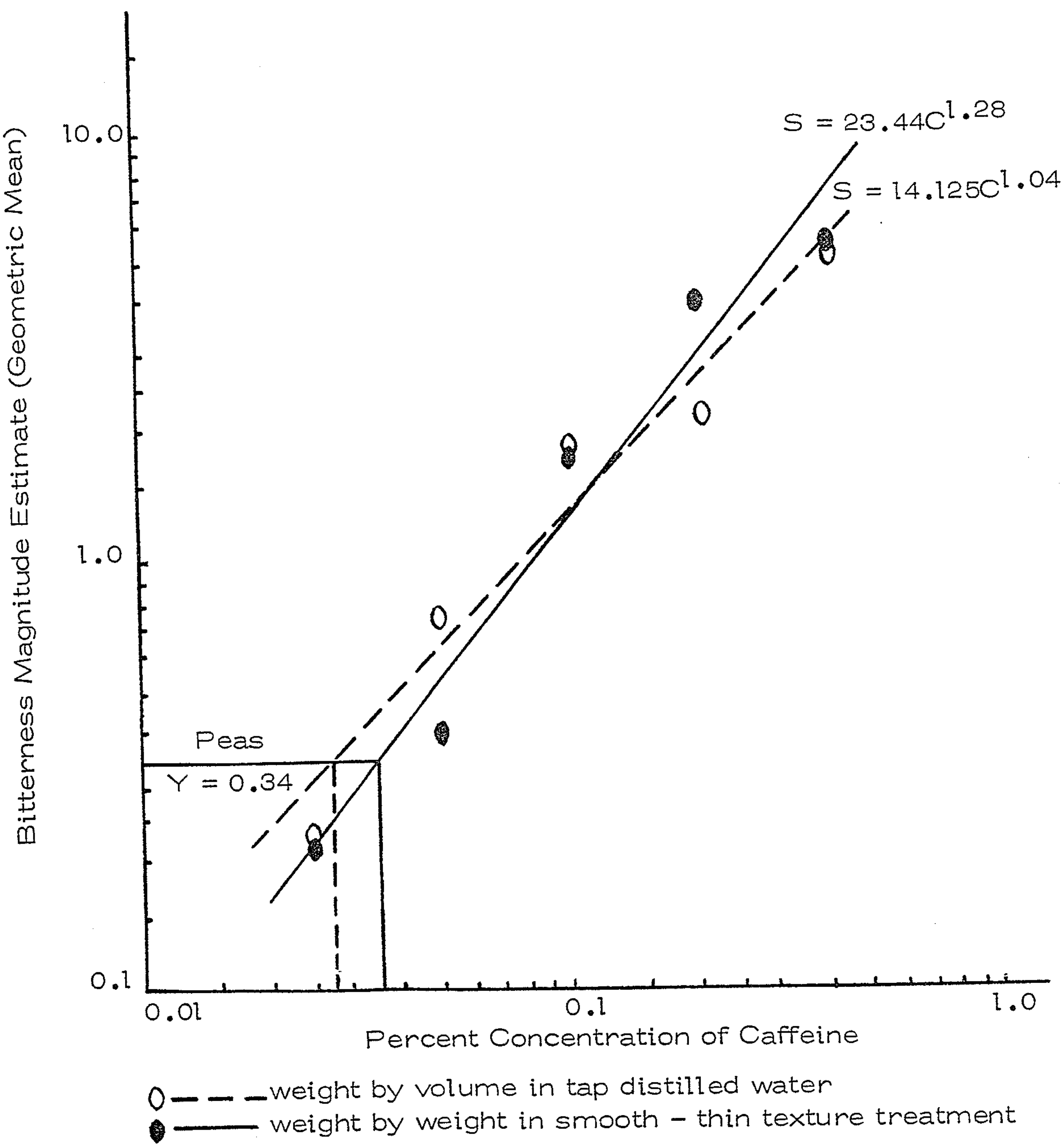


Table 5

Model System Formulations*

Treatment	Smooth Base	Pulpy Base	Water	Puréed Pears	Puréed Potatoes	Liquified Potatoes	Sucrose		Citric Acid		Caffeine	
	grams	grams	grams	grams	grams	grams	grams	%w/w	grams	%w/w	grams	%w/w
Smooth-Thick	100	--	--	--	--	--	2.050	2.00	--	--	--	--
Smooth-Thin	100	--	23.125	--	--	--	1.875	1.50	--	--	--	--
Pulpy	--	100	23.750	--	--	--	1.250	1.00	--	--	--	--
Gritty-Grainy	100	--	--	1.0	--	--	1.540	1.50	--	--	--	--
Chalky-Drying	100	--	33.610	--	--	4.0	1.390	1.00	--	--	--	--
Grainy-Gummy-Mouth-coating	100	--	19.062	--	5.0	--	0.938	0.75	--	--	--	--
Sweet	100	--	12.500	--	--	--	12.500	10.00	--	--	--	--
Sour	100	--	24.812	--	--	--	--	--	0.188	0.15	--	--
Bitter	100	--	23.075	--	--	--	1.875	1.50	--	--	0.05	0.04

* for 100 grams of base.

All treatments were transferred from the preparatory containers into sample cups, covered tightly with lids and immediately frozen at -20°C until required.

III. PRIMARY TRAINED PANEL EVALUATION

The sensory testing procedure is given in Section II C 1. A six membered trained panel evaluated the nine model systems for three taste and seven textural characteristics. Three sessions were held each week for a total of three weeks, completing three replications for each treatment. Panelists were presented with three treatments per session, a set of reference standards (Table 2) and a ballot (Appendix F). The order of treatment presentation was randomized.

The night before a session, the treatments were removed from the freezer and thawed overnight under refrigeration. On the morning of testing, they were removed from the refrigerator at least two hours before panelists were due to arrive. Reference standards stored in the refrigerator were treated similarly.

IV. ANALYSES OF SENSORY DATA

A. Normalization of Magnitude Estimates

Magnitude estimation is a free number scaling system. Therefore, the size of panelists' numbers contributes much of the variation between their judgements and may mask main treatment effects. The data were normalized to put all judges on the same scaling continuum without affecting the ratio differences among their judgements. The geometric mean of each panelist's estimates was calculated across treatments and replications. Each of their scores was then divided by their respective geometric mean. The values for the reference standards (ten) were included in the scores normalized. The normalized data were further transformed to a logarithmic normal distribution and a three-way analysis of variance was applied.

B. Treatment of "NP" Judgements

The frequencies of not present ("NP") judgements given in each treatment were calculated. If more than one-third of the judgements were "NP", that treatment's scores were excluded from the analysis. Otherwise, "NP" judgements were replaced by positive numerical values and the treatment scores were normalized.

Values of zero cannot be used in magnitude estimation since they make it impossible to calculate a panelist's geometric mean. By definition, the values substituted for "NP" have to be smaller than a panelist's minimum numerical judgement for a given sensory characteristic. The values also should not drastically alter the elevation of a panelist's judgements.

Table 6 contains the results of preliminary analyses conducted to determine the most appropriate values to substitute for "NP". Twenty-two individual test cases were selected from the data. The selected cases differed in the number of "NP" judgements a panelist had given, the size of their minimum numerical judgement and the number of treatment scores to be included in the analysis. For each test case, values of ten to ninety percent of a panelist's minimum numerical judgement were substituted for their "NP" scores and the data were normalized. It was generally found that by substituting eighty percent of the minimum value for "NP", the elevation of the normalized data was not changed by more than ten percent. This finding was relatively independent of the three variables tested.

For example, in test case ten, a panelist gave two "NP's", their minimum numerical judgement was 3.00 and eight treatment scores were included in the analysis. It was found that substituting any less than seventy-eight percent of the minimum value (3.00) for "NP" resulted in more than a ten percent change in the elevation of the data. The findings were similar for test case thirteen. However, in this case, the panelist had given three "NP's", their minimum value was 0.50 and eleven treatment scores were normalized.

Table 6

Determination of Values for "NP" Resulting in Not More Than a Ten Percent Elevation Change in Normalized Data Over Three Variables in Selected Test Cases

Test Case	Variable: Number of "NP" Scores Given	Variable: Minimum Numerical Score Given	Variable: Number of Scores Normalized	Percent of minimum score resulting in ≤ 10% change in elevation of normalized data
1	1	0.20	11	80.4%
2		0.50	11	79.6
3		1.00	8	79.5
4		3.00	8	79.9
5		5.00	11	80.2
6	2	0.10	7	78.0
7		0.25	11	79.5
8		0.50	10	79.0
9		1.00	8	78.4
10		3.00	8	78.2
11		5.00	8	78.3
12	3	0.10	10	76.9
13		0.50	11	77.9
14		1.00	11	77.8
15		3.00	8	75.9
16		5.00	9	76.8
17	4	0.50	10	75.1
18		1.00	11	76.5
19		3.00	8	73.0
20		7.00	10	75.8
21	5	0.10	10	72.8
22		0.50	11	74.9

Therefore, "NP" scores were replaced by values of eighty percent of a panelist's minimum numerical judgement given for a particular sensory characteristic.

V. INFANT FEEDING TRIAL

A. Experimental Plan

The study was designed as a randomized complete block. Each infant received all of the model system treatments. A randomized feeding order (Appendix G) was randomly assigned to each subject. A set of nine samples was prepared for each infant and labeled as to on which days of the study they were to be fed.

In a similar study, Harasym (1977) investigated infant acceptance of four types of Heinz commercial and home-prepared vegetables. Each form of the vegetable types was fed for three consecutive days. Analysis of these data revealed that the change in infant response from Day 2 to 3 of feeding followed a normal distribution (Appendix H). Therefore, in this study the samples were only fed for two consecutive days.

B. Contact of Subjects

Forty-nine infants participated in the study. The subjects were all less than ten months of age and were receiving a full range of non-milk foods including juice, cereal, fruit, vegetables and meat.

The majority of the subjects were contacted through the nutrition section of the St. Boniface General Hospital Prenatal Clinic. Permission to contact attendants of the Clinic was granted by the Head of Obstetrics and Gynaecology at the St. Boniface Hospital (Appendix I). A letter (Appendix J) was sent to parents whose infants were born in August to December, 1977. The letters were followed by a telephone call. Four parents known by the experimenter were also contacted and two mothers were referred by previous contacts.

If a subject were on a full range of semi-solids, a convenient date was arranged for delivery of supplies and home interviews. If all types of semi-solids had not yet been introduced, mothers were instructed to introduce them when they wished. The mothers were contacted periodically until the infant was ready to start the study.

C. Delivery of Supplies and Home Interviews

When infants were ready to start the study, their assigned set of samples was taken to their homes along with the necessary forms. The samples were transported on dry ice in a styrofoam cooler to maintain their frozen state. One to one and one-half hours were spent with each mother.

1. Instructions for Handling Samples

Mothers were presented with their set of samples which were immediately placed in frozen storage. They were instructed that the study was to run for eighteen consecutive days and that each sample was to be fed for two consecutive days.

All mothers were given a list of instructions for handling and feeding the samples (Appendix K). The scheduled sample was to be served at room temperature on the appropriate days of the study before one of the infant's regular meals. The noon feeding was preferred but if this were not feasible, it was stressed that the samples were to be fed at approximately the same time each day. Mothers were requested not to taste the samples to ensure that their attitude did not influence the infant's reaction or bias the mother's recordings. Mothers were instructed to offer enough sample to obtain the infant's reaction to it and complete the appropriate observation sheet.

2. Observation Sheets

Mothers were given a set of eighteen identical observation sheets (Appendix L) which were numbered to correspond with the samples. The instrument used to measure degree of preference was a five-point hedonic scale ranging from obviously likes to obviously dislikes. Mothers were asked to check off the scale point which best reflected their infant's reaction to a sample. Written descriptions of infant reactions representing each scale point were adapted from Harasym (1977) and provided for mothers to use as a guide (Appendix L).

3. Questionnaire

The researcher administered a questionnaire (Appendix M) to all mothers to obtain background feeding practices and food preferences for each subject. Background information such as birth date and weight was also collected. In determining background feeding preferences, mothers were presented with the scale found on the observation sheets for the study (Appendix N). The scale was reviewed with each mother. They were asked to indicate their infant's reaction to a food group or specific product based on the five scale points.

4. Consent Form

Each mother signed a consent form (Appendix O) agreeing to the conditions of the study and confirming their voluntary participation in the project.

D. Collection of Results

The project took five months to complete. Results were collected between April and August, 1978. Mothers were requested to call the researcher when they had finished the study and results were collected from each home. The observation sheets were reviewed with each mother and they were informed as to the specific nature of each sample.

E. Statistical Analyses of Results

1. Determination of Acceptance Scores

The following numerical values were assigned to the infants' acceptance of the treatments, as recorded by their mothers:

5 = Obviously Likes

4 = Seems to Like

3 = Indifferent

2 = Seems to Dislike

1 = Obviously Dislikes

The change in infant response to the treatments from Day 1 to 2 of feeding was found to follow a normal distribution (Appendix P). Therefore, a subject's mean acceptance score for each treatment was calculated and all statistical analyses were applied to these data.

2. Missing Observations

All forty-nine subjects completed the study. However, there was a total of eight missing observations (less than one percent). In two cases, a treatment was fed for only one day. Based on the normality of infant response to the treatments from Day 1 to 2 of feeding, these values were used as the subjects' mean treatment acceptance score. Observations for three treatments were completely missing. Values to be used in the statistical analyses were calculated using the formulas found in Appendix Q.

3. Analyses

Nonparametric statistical methods were used to analyze the data since a normal distribution could not be assumed. The scale points and thus the data were discrete. The results were analyzed in five different ways. The initial analysis included all forty-nine subjects and Friedman's Analysis of Variance by Ranks was used.

Kruskal -Wallis Analysis of Variance by Ranks was applied in the remaining analyses. Subjects were divided into three age groups to test the effect due to age. The effects of the following background feeding practices were also tested:

1. the introduction of fruits before or at the same time as vegetables by dividing subjects into two groups
2. the subjects' age of first regular introduction to semi-solids by comparing three groups

3. the number of months the infants had been fed semi-solids prior to the study by dividing them into four groups.

Duncan's Multiple Range Test, adapted for use with nonparametric statistics, was used to determine where significant differences lay. Differences in the rank totals for each treatment group were tested. The standard error of the rank totals was calculated using the formula found in Appendix R.

RESULTS AND DISCUSSION

I. DESCRIPTION OF SAMPLE

A. General

The sample consisted of thirty males and nineteen females whose ages ranged from four to nine and one-half months. All subjects were normal, healthy infants. In the following sections, the sample will be described in terms of their past feeding experiences, as reported by their mothers through the questionnaire. Due to the bias in sample selection, the degree to which these findings reflect current infant feeding practices is not certain.

B. Age of Subjects

The subjects' ages when they began the study are given in Table 7. The majority of the subjects (91.8%) were between five and eight months old when they started the study. Two infants were less than five months and another two subjects were more than eight months of age.

All subjects were reported to have exhibited some signs of teething such as drooling and sore gums. The majority of the subjects (65.3%) had not cut any teeth at the time of the study. One infant in the eldest age group had cut six teeth. The remaining

Table 7

Description of Sample by Age of Subjects
(N=49)

Age	Number of Subjects	Percentage
$\leq$ 6 months	16	32.7%
$>$ 6 $\leq$ 7 months	18	36.7%
$>$ 7 months	15	30.6%

subjects had cut either one or two teeth and numbered two (4.1%) in the youngest age group, five (10.2%) in the middle and nine (18.4%) in the eldest age group. The number of infants with teeth approximately doubled between the three age groups.

C. Major Milk Sources

1. At Birth

Almost ninety percent of the subjects were either totally or partially breast-fed at birth (Table 8.1). This finding supports the recently reported trend in the literature towards an increased incidence of breast-feeding early in life (De Swiet et al, 1977; Cunningham, 1977; Bramble and Miles, 1978; Bergerman et al, 1978; Clark, 1978; Tse et al, 1978). The remaining subjects received a commercial milk formula at birth.

2. At the Time of the Study

Table 8.2 contains the subjects' major milk sources at the time of the study. Approximately thirty percent of the subjects were still totally or partially receiving breast milk as a major milk source. Fifty-six percent of the infants totally breast-fed at birth in this study were nursed for four months or longer. This finding is consistent with reports in the literature which indicate that, when initiated, breast-feeding is often continued

Table 8.1

Description of Sample by Major Milk Source at Birth
(N=49)

Type of Milk	Number of Subjects	Percentage
Breast	41	83.7%
Breast/Commercial Formula*	2	4.1%
Commercial Formula**	6	12.2%

* Similac
** Similac, Similac with Iron, Enfalac, SMA

Table 8.2

Description of Sample by Major Milk Source at the Time of the Study (N=49)

Type of Milk	Number of Subjects	Percentage
Breast	10	20.4%
Breast/2% or Whole Milk	5	10.2%
Whole Milk	11	22.5%
Two Percent Milk	12	24.5%
Commercial Formula*	10	20.4%
Home Prepared Formula**	1	2.0%

* Similac, Enfalac, SMA
** Whole milk, water and corn syrup

for three to three and one-half months postpartum (Salber and Feinleib, 1966; Harris and Chan, 1969; Cole, 1977; Bramble and Miles, 1978; Tse et al, 1978; Ferris et al, 1978a).

Of those infants partially breast-fed at the time of the study, four were in the process of being weaned to two percent milk and one to whole milk. One infant was receiving a formula prepared from whole milk. By combination, this raises the total number of subjects receiving two percent as a major milk source to sixteen (32.7%) compared to thirteen (26.5%) receiving whole milk. Therefore, over one-half of the subjects receiving cows' milk were fed two percent. The use of two percent milk as an alternative to whole milk may reflect the current concern over infant obesity. However, this practice is not recommended for infants less than one year of age (Manitoba Department of Health and Social Development, 1976).

At the time of the study, ten infants were receiving commercial formulas. Eight subjects were fed these formulas, either totally or partially, at birth (Table 8.1). Fomon (1971) and Maslansky et al (1974) reported that after three months of age, the use of commercial milk formulas decreases rapidly and the use of cows' milk increases proportionately. In this study, the use of commercial formulas did not decrease but remained relatively constant from birth to approximately eight months of age. Harasym (1977) similarly found that total or partial use of commercial formulas was constant from birth until five months of age. The increased incidence of cows' milk feedings from birth (Table 8.1) until the time of the study was found in infants who were breast-fed initially and eventually weaned onto this milk source.

D. Introduction to Non-Milk Foods

1. Age of First Introduction to Semi-Solids

Close to one-third of the subjects were receiving some type of semi-solid at less than two months of age (Table 9.1). By four months of age, two-thirds of the infants had been introduced to semi-solids. The infants in this study were introduced to semi-solids at a later age than has been reported in the literature (Beal, 1957 and 1969; Mackey and Orr, 1978; Maslansky et al, 1974; Ounsted and Sleigh, 1975; Guthrie, 1966). This may be related to the high incidence of breast-feeding found among the subjects in the early months of life. Numerous investigators have reported that breast-fed infants are started on semi-solids later than bottle-fed infants (Neumann and Alpaugh, 1976; Cole, 1977; Bramble and Miles, 1978; Ounsted and Sleigh, 1975; De Swiet et al, 1977). In addition, the current recommendation is that semi-solids be introduced at later ages than they have been in the past (Manitoba Department of Health and Social Development, 1976).

Table 9.1

Description of Sample by Age of First Introduction to Semi-Solids (N=49)

Age	Number of Subjects	Percentage	Cumulative Percentage
< 2 months	15	30.6%	30.6%
2< 4 months	18	36.7%	67.3%
4< 6 months	16	32.7%	100.0%

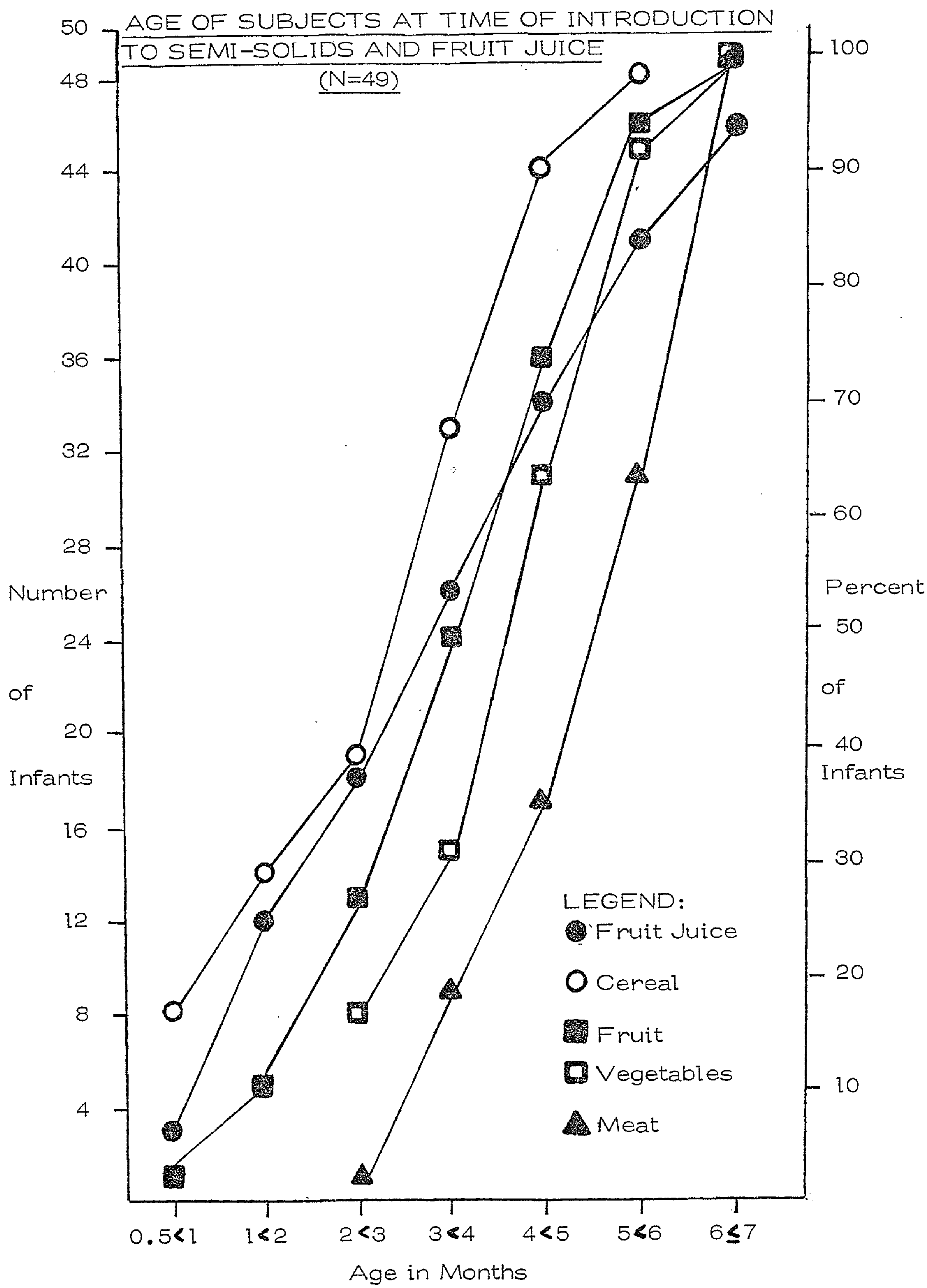
Forty-two of the forty-nine subjects (85.7%) received cereal as their first food experience. Rice was the first type of cereal fed to ninety-four percent of the infants. Cereal has frequently been reported to be the first food added to an infant's diet (Ferris et al, 1978b; Pipes, 1977; Harasym, 1977; Harris and Chan, 1969; Salber and Feinleib, 1966). Both Ferris et al (1978b) and Harris and Chan (1969) similarly found that rice cereal was the most frequently used cereal initially. Of the remaining seven subjects, six infants (12.3%) were introduced to fruit first. Meat was the first type of semi-solid regularly fed to one subject.

2. Overall Age of Introduction to Non-Milk Foods

The ages at which the subjects in this study were introduced to semi-solids and fruit juice are graphically illustrated in Figure 5. Three of the subjects did not receive fruit juice on a regular basis and one subject was not fed cereal regularly.

Almost forty percent of those subjects who received fruit juice (N=49) had tasted it by three months of age. This finding is consistent with those of Maslansky et al (1974) and Ferris et al (1978b). Semi-solids were consistently introduced at ages earlier than are recommended (Manitoba Department of Health and Social Development, 1976) but later than those reported by other authors. Three months is the earliest age recommended to first introduce semi-solids into an infant's diet. By three months of age, almost

Figure 5


AGE OF SUBJECTS AT TIME OF INTRODUCTION
TO SEMI-SOLIDS AND FRUIT JUICE
(N=49)
Number of Infants
50
48
44
40
36
32
28
24
20
16
12
8
4
Percent of Infants
100
90
80
70
60
50
40
30
20
10
LEGEND:
Fruit Juice
Cereal
Fruit
Vegetables
Meat
0.5<1
1<2
2<3
3<4
4<5
5<6
6≤7
Age in Months

forty percent of the subjects (N=49) had been introduced to cereal, twenty-six percent had fruit, sixteen percent had vegetables and one infant had been fed meat (N=49). However, Harris and Chan (1969), Maslansky et al (1974), Harasym (1977) and Ferris et al (1978b) observed that at this same age, over twice as many infants had been started on each type of semi-solid.

Cereal was uniformly introduced to the subjects before fruit juice. Ferris et al (1978b) also found that fruit juice was not the first non-milk food offered to infants. Semi-solids were generally introduced in the order of cereal, fruit, vegetables and meat. This is reportedly the usual order of solids introduction (Harris and Chan, 1969; Maslansky et al, 1974, Beal, 1957; Ferris et al, 1978b; Harasym, 1977). However, it is not compatible with that currently recommended. The Manitoba Department of Health and Social Development (1976) recommends that fruit be introduced after vegetables to encourage acceptance of the latter. However, vegetables were introduced before fruit to only ten (20.4%) of the infants. Table 9.2 contains the order in which fruit and vegetables were introduced to the subjects.

The infants in this study were not introduced to semi-solids as early as is indicated in the literature. This may be related to the fact that almost fifty percent of the subjects received only breast milk as their major milk source for four months or longer. It would also indicate that more mothers are currently following

Table 9.2

Description of Sample by Order of Fruit and Vegetable Introduction (N=49)

Order of Introduction	Number of Subjects	Percentage
Fruit before vegetables	35	71.4%
Simultaneously	4	8.2%
Vegetables before fruit	10	20.4%

the recommendation of not introducing semi-solids until three to six months of age than have in the immediate past (Harasym, 1977; Ferris et al, 1978b).

3. Number of Months on Semi-Solids Prior to Study

At the time of the study, the subjects had been receiving semi-solids regularly for various lengths of time. Some subjects had been fed solids for less than three months while others had received them for more than five months (Table 9.3).

4. Basis for Introduction to Semi-Solids

Over one-half of the mothers (53.1%) followed their own initiative in deciding when to introduce semi-solids. Another forty-one percent followed the advice of their physician. One mother's decision stemmed from a prenatal class and another's from a public health nurse. The grandmother of one infant introduced semi-solids whereas the mother would not have at that time.

Table 9.3

Description of Sample by Number of Months on Semi-Solids Prior to Study (N=49)

Number of Months	Number of Subjects	Percentage
< 3	10	20.4%
$3 < 4$	17	34.7%
$4 < 5$	13	26.5%
≥ 5	9	18.4%

II SUMMARY OF ANALYSES

A summary of the analyses used to determine infant acceptance and the sensory characteristics of the model system samples is found in Table 10. In determining infant acceptance, the data were analyzed in five different ways. The mean acceptance scores from all forty-nine subjects were included in each analysis. A trained panel evaluated the treatments for the sensory characteristics listed in this table. The relationship between infant acceptance and the sensory characteristics of the treatments will be discussed in subsequent sections.

Table 10

Summary of Analyses of Infant Acceptance and Sensory Evaluation of Model System Samples

Treatments Tested

Sweet
Sour
Bitter
Smooth - Thick
Smooth - Thin
Pulpy
Gritty - Grainy
Chalky - Drying
Grainy - Gummy - Mouthcoating

I Infant Feeding Trial

Analyses:

1. Overall Acceptance (N=49)
   Friedman's Analysis of Variance by Ranks

2. Age Groups
   Age 1 ($\leq$ 6 months) (n=16)
   Age 2 ($>$ 6 $\leq$ 7 months) (n=18)
   Age 3 ($>$ 7 months) (n=15)

3. Background Feeding Practices
   A. Order of Fruit and Vegetable Introduction
      Fruit 1 (=2) (fed fruits first or simultaneously with vegetables) (n=39)
      Fruit 2 (fed vegetables first) (n=10)

II Trained Panel Sensory Evaluation

Taste Intensities: Sweetness, Sourness, Bitterness

Textural Characteristics: Viscosity, Particle Size, Amount of Particles, Pulpyness, Gumminess, Dryness, Mouthcoating

Analyses: Analysis of Variance

continued

Table 10 cont'd

3. Background Feeding Practices

B. Age of Semi-Solid Introduction
Intro 1 (< 2 months) (n=15)
Intro 2 (2 ≤ 4 months) (n=18)
Intro 3 (4 ≤ 6 months) (n=16)

C. Months on Semi-Solids
Fed 1 (≤ 3 months) (n=10)
Fed 2 (3 < 4 months) (n=17)
Fed 3 (4 < 5 months) (n=13)
Fed 4 (≥ 5 months) (n=19)

2 + 3 - Kruskal - Wallis Analysis of Variance by Ranks

III SENSORY CHARACTERISTICS OF MODEL SYSTEM SAMPLES

A. Analyses

The normalized data generated by the trained sensory panel were analyzed at the five percent level of significance using a factorial analysis of variance with three replications in each cell. One analysis was conducted for each of the ten sensory characteristics assessed by the panel. The reference samples were included in the analysis of their respective sensory characteristic. Significant main effects due to treatments were found in every case ($p < 0.001$). The analysis of variance tables are found in Appendix S. The panelist sums of squares (5df) were consistently found to equal zero. This is a direct consequence of analyzing the logarithms of the normalized data and its basis can be illustrated mathematically (Dr. K. Mount, Department of Statistics, University of Manitoba, Personal Communication, 1978).

Significant judge by replication and/or treatment by judge interactions were found in nine of the ten analyses. Treatment by judge interaction indicates that panelists are scoring the treatments differently for a given sensory characteristic. Judge by replication interaction means that a panelist's scores for a treatment are not consistent over the replications. Duncan's Multiple Range Test is a method of multiple comparisons of treatment means used to determine where significant differences between treatments lay. However, this test should not be used in the presence of significant interactions since the results would be questionable. Differences may be found which are due to interaction and not due to treatments. No significant interactions were revealed in the bitterness analysis. Therefore, Duncan's Test was conducted on the bitterness mean scores to determine where the significant differences lay. For the remaining nine sensory characteristics, the mean magnitude estimates by judge over replications were calculated and are contained in Tables 11 to 19. Any reference to differences between treatments will be based on these tables for all of the sensory characteristics assessed except bitterness. Because the samples used in this study were designed to be model systems, only extreme differences in the sensory characteristics of the treatments will be discussed.

The panel did not perform as well as was expected as is evidenced by the significant interactions. Treatment by judge interaction indicates that the panel did not have a unified understanding of how a sensory characteristic was perceived in the mouth. Highly significant ($p = 0.001$) treatment by judge interactions were found for the characteristics of sourness, viscosity, gumminess, dryness and mouthcoating. This may limit inference to differences between treatments for these sensory characteristics particularly.

In presenting the results of the analyses, the following abbreviations will be used for the names of the treatments:

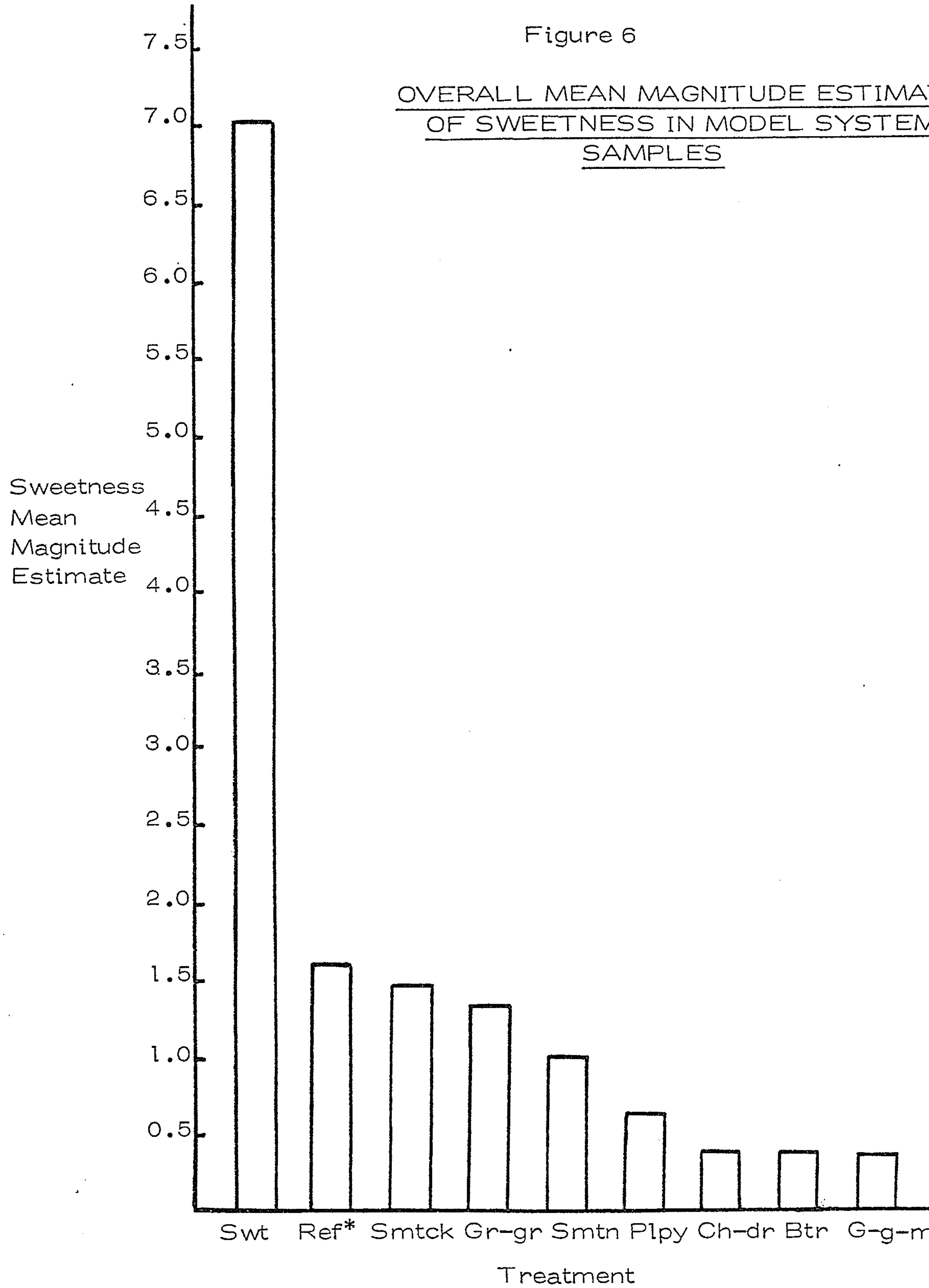
Sweet	=	SWT
Sour	=	SOUR
Bitter	=	BTR
Smooth - Thick	=	SMTCK
Smooth - Thin	=	SMTN
Pulpy	=	PLPY
Gritty - Grainy	=	GR - GR
Chalky - Drying	=	CH - DR
Grainy - Gummy - Mouthcoating	=	G - G - M

B. Sweetness

Sweetness was found in eight of the nine model system treatments. No sweetness was present in the sour treatment. The sweet treatment was clearly sweeter than the others (Figure 6). It can be seen in Table 11 that all judges consistently scored the sweetness of this treatment much higher than that of the remaining seven treatments in which sweetness was perceived. The degrees of sweetness perceived in the other treatments were slight compared to that present in the sweet treatment. The sweetness of the former treatments can be attributed to the small quantities of sucrose added in their formulations to mask their initial sourness (Table 5).

Figure 6

OVERALL MEAN MAGNITUDE ESTIMATES OF SWEETNESS IN MODEL SYSTEM SAMPLES



*Reference = 2.0% Sucrose Weight by Volume in Tap Distilled Water

Table 11

Mean Magnitude Estimates of Sweetness in Treatments by Judge over Replications

Treatment	Sweetness Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference *	2.14	0.68	1.91	4.32	1.28	1.21
SWT	4.14	4.96	6.30	8.63	20.35	5.41
BTR	0.49	0.66	0.55	0.21	0.35	0.33
SMTCK	0.92	1.34	1.26	1.82	2.76	1.30
SMTN	0.84	1.09	0.52	2.17	0.55	1.92
PLPY	0.49	1.04	0.58	1.37	0.41	0.47
GR - GR	1.49	1.93	1.50	0.99	1.02	1.36
CH - DR	0.83	0.43	1.03	0.12	0.20	0.52
G - G - M	0.49	0.35	0.26	0.20	0.86	0.56

* Reference = 20% Sucrose Weight by Volume in Tap Distilled Water

C. Sourness

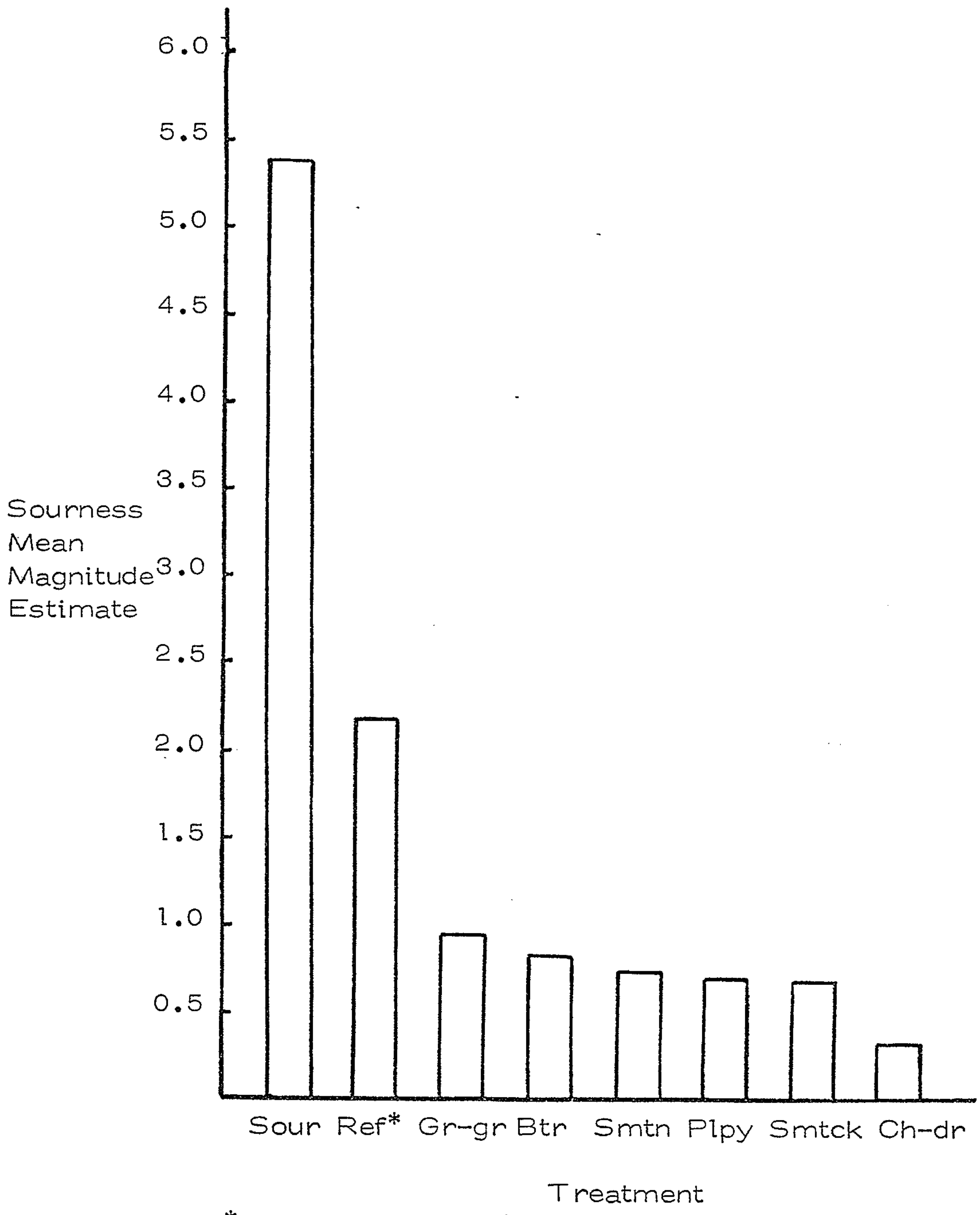
Sourness was not found in the sweet and grainy - gummy - mouthcoating treatments. The sour treatment was substantially more sour than the remaining treatments (Figure 7). The mean sourness estimates of all judges were much greater for the sour treatment than for the others (Table 12). In the remaining six treatments where sourness was judged to be an important characteristic, the degrees of sourness present were negligible compared to that in the sour treatment. The sourness in these treatments was due to the initial sourness of the base from which they were prepared. It appears that the quantities of sucrose added in their formulations were not sufficient to completely mask the sourness of these treatments. However, had more sucrose been added, the treatments would have possessed higher degrees of sweetness. This was not desirable for the purpose of this investigation. The aim was to keep the taste intensities of the texture treatments as uniform and as bland as possible.

D. Bitterness

Figure 8 shows the panel's mean magnitude estimates of bitterness found in the bitter and gritty - grainy treatments. Bitterness was not perceived in the remaining treatments. The bitter treatment was significantly more bitter than the gritty - grainy treatment ($p = 0.01$). It was rated as being about seven times

Figure 7

OVERALL MEAN MAGNITUDE ESTIMATES OF SOURNESS IN MODEL SYSTEM SAMPLES



*Reference = 0.02% Citric Acid Weight by Volume in Tap Distilled Water

Table 12

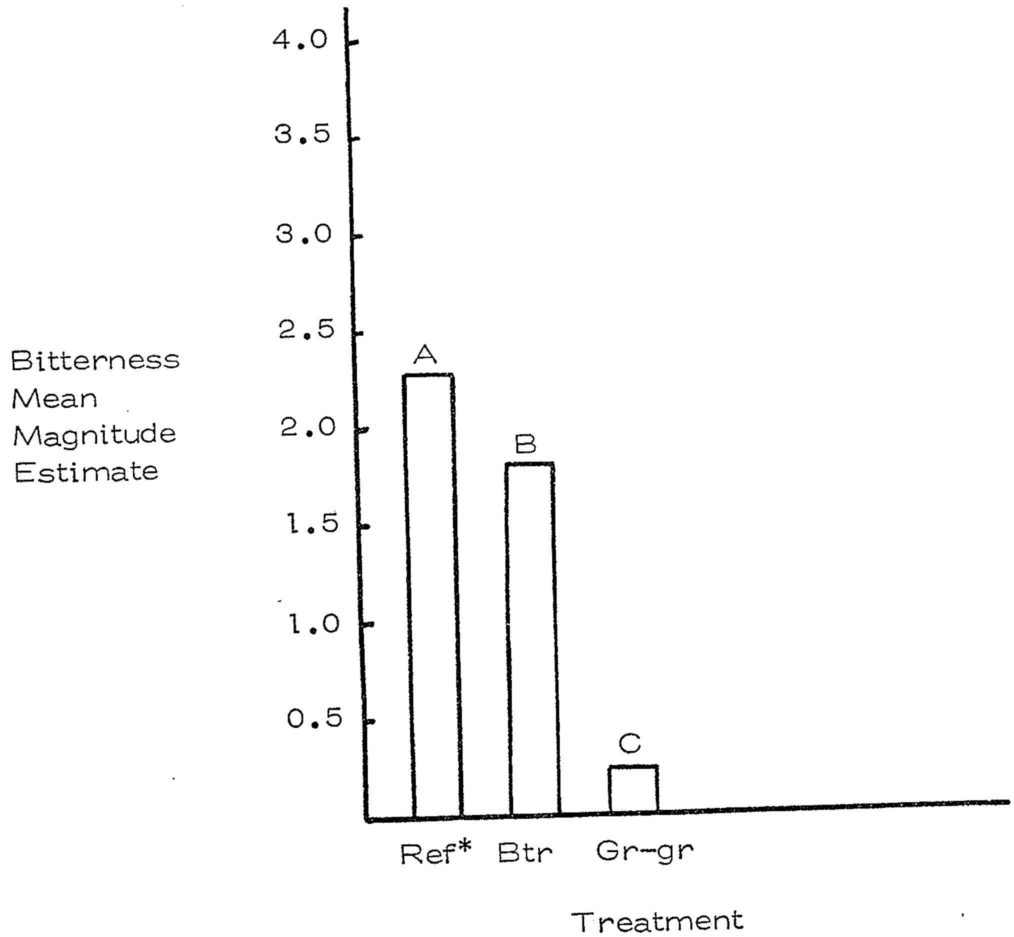
Mean Magnitude Estimates of Sourness in Treatments by Judge over Replications

Treatment	Sourness Mean Magnitude Estimate by Judge					
	1	2	3	4	5	6
Reference*	2.11	0.89	1.65	3.21	1.84	6.14
SOUR	3.24	3.40	5.44	6.43	6.78	9.40
BTR	1.26	1.59	0.28	0.34	1.78	0.97
SMTCK	0.77	0.91	0.71	1.32	0.33	0.45
SMTN	1.04	0.97	1.13	0.67	0.37	0.57
PLPY	0.63	1.02	0.88	0.74	0.58	0.45
GR - GR	0.73	0.72	0.98	1.14	2.41	0.57
CH - DR	0.31	0.32	0.59	0.19	0.27	0.26

*Reference = 0.02% Citric Acid Weight by Volume in Tap Distilled Water

Figure 8

OVERALL MEAN MAGNITUDE ESTIMATES OF BITTERNESS IN MODEL SYSTEM SAMPLES



DUNCAN'S MULTIPLE RANGE TEST (p = 0.01)

A B C

*Reference = 0.05% Caffeine Weight by Volume in Tap Distilled Water.

more bitter than the latter treatment. The slight degree of bitterness found in the gritty - grainy treatment was most likely due to the pears added in the preparation of this treatment.

E. Viscosity

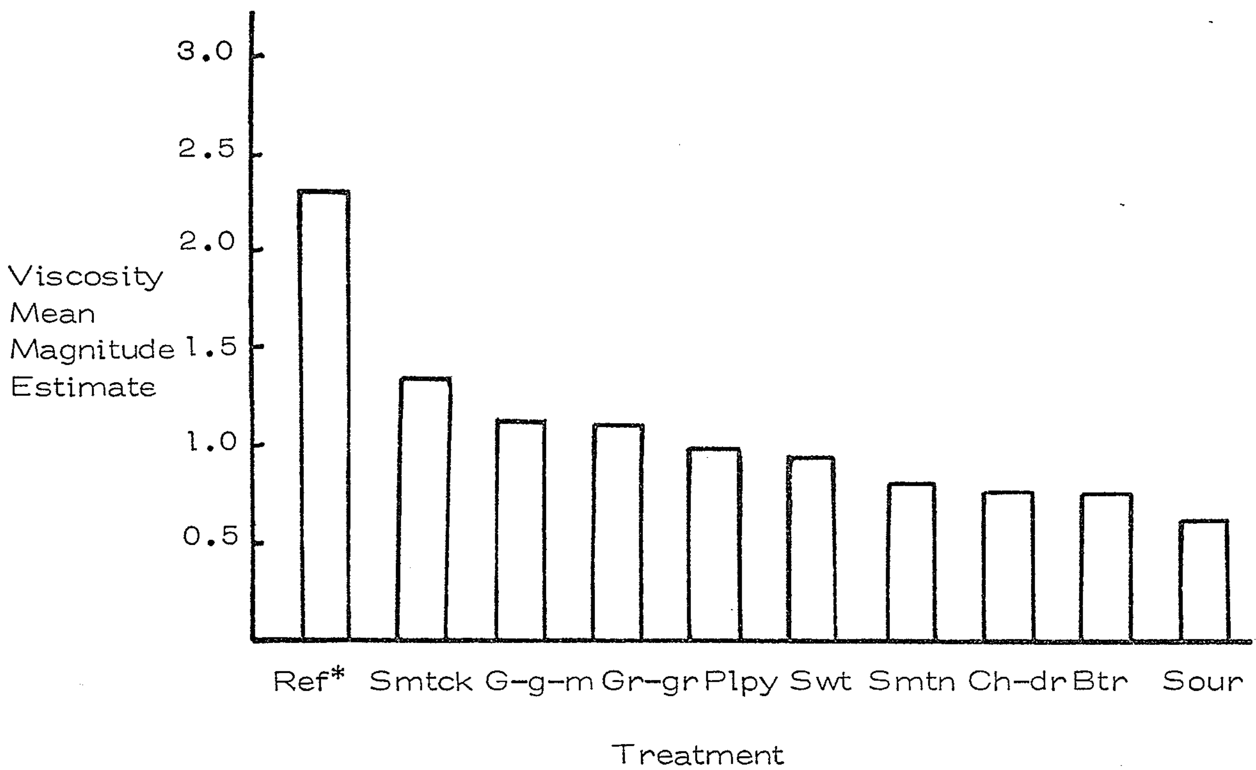
The overall mean magnitude estimates of viscosity in the model system treatments are illustrated in Figure 9. Highly significant ($p = 0.001$) treatment by judge and judge by replication interactions were found for this characteristic. This indicates that the panel found viscosity very difficult to judge.

Examination of the data in Table 13 reveals that, generally, the panel's viscosity estimates were similar for all treatments. Contrary to intentions, the smooth - thick treatment was not considerably more viscous than the smooth - thin treatment. The maximum viscosity obtainable in the system was limited. In preparing the smooth base, it was allowed to drain completely (Appendix B). However, after this point, no further increases in viscosity were possible. Water was added in some of the treatment formulations to make them equivalent in viscosity to their commercial counterparts (Table 3, Table 5). Although they did not differ greatly, the viscosities of the smooth - thick and smooth - thin treatments were representative of those found in Heinz strained infant foods.

Part of the panel's difficulty in assessing viscosity may have been due to the reference standard. The sweetened condensed milk

Figure 9

OVERALL MEAN MAGNITUDE ESTIMATES OF VISCOSITY IN MODEL SYSTEM SAMPLES



*Reference = Sweetened Condensed Milk

Table 13

Mean Magnitude Estimates of Viscosity in Treatments by Judge over Replications

Treatment	Viscosity Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference*	2.19	2.72	3.36	1.38	1.77	3.18
SWT	1.14	0.67	1.17	1.00	1.04	0.83
SOUR	0.80	0.68	0.77	0.86	0.30	0.40
BTR	0.70	0.56	0.83	0.86	0.87	0.66
SMTCK	1.08	1.48	0.88	1.14	4.06	0.92
SMTN	0.72	0.77	0.88	1.00	0.58	1.01
PLPY	1.02	1.06	0.66	1.10	1.50	0.78
GR – GR	1.00	1.06	1.11	1.31	1.16	0.99
CH – DR	0.86	0.77	0.70	0.87	0.38	1.26
G – G – M	1.04	1.42	1.02	0.69	1.31	1.58

*Reference = Sweetened Condensed Milk

reference was found to be more viscous than any of the treatments. Although it was diluted with water in its preparation (Table 2), it should have been diluted further. The intensity of a characteristic in a reference food product should ideally be intermediate to the intensities found in the treatments. This ensures that treatment ratings are not inflated or deflated due to the intensity of the reference standard. The significant difference in viscosity revealed in the analysis may have only been between the sweetened condensed milk reference and the treatments. Standardization of technique for viscosity evaluation was also difficult. Viscosity in the mouth is assessed by measuring the force required to make a sample flow. It is impossible to ensure that all panelists are applying the force in the same way. Finally, the range of subjective viscosity is very narrow (Moskowitz et al, 1972; Kapsalis and Moskowitz, 1977). This means that unless two samples differ greatly in physical viscosity, panelists will have difficulty perceiving the difference. This appears to be the case with the model system samples used in this study.

F. Particle Size

The grainy - gummy - mouthcoating treatment was designed to contain large particles to simulate those which are found in strained meat products. The particles in this treatment were found to be much larger than those in either the chalky - drying or gritty - grainy treatments.

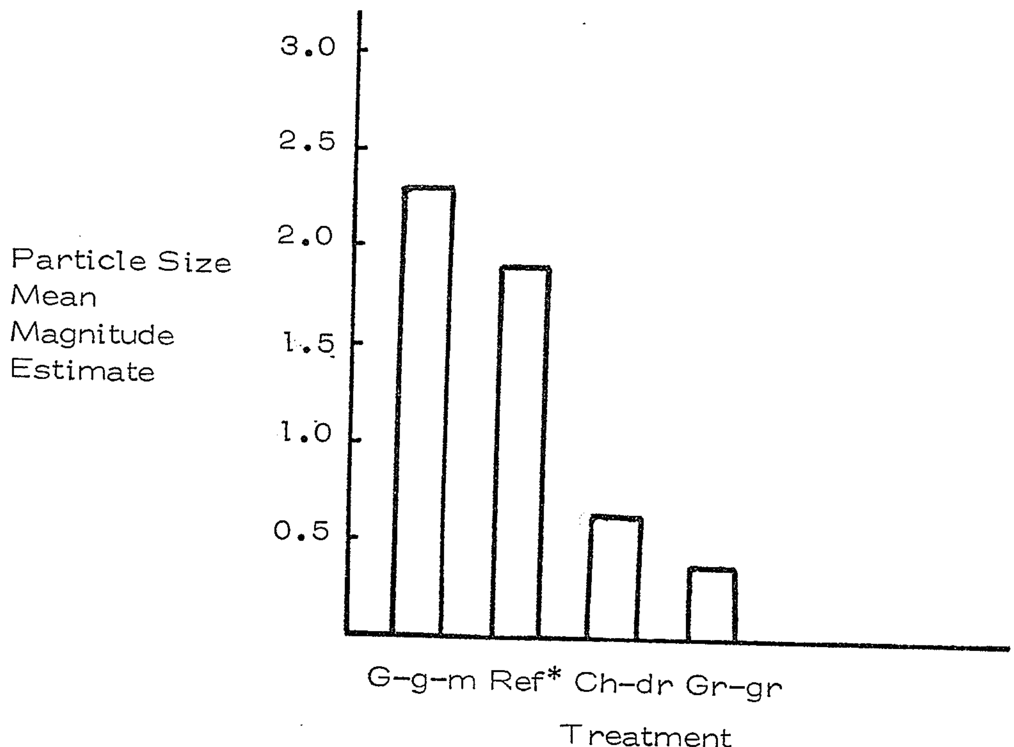
This can be seen in both Figure 10 and Table 14. The remaining six treatments did not contain any distinct particles. The chalky - drying treatment was intended to contain the smallest particles. Chalky is defined as large numbers of very small particles. The liquified potatoes added to this treatment were puréed to a greater extent than the pears added to the gritty - grainy treatment (Appendix B). However, the size of the particles in the chalky - drying treatment were rated as being larger than those in the gritty - grainy treatment by all judges except Judge 1 (Table 14). The difference in particle size between these two treatments may not be large enough to be significant.

G. Amount of Particles

Figure 11 gives the overall mean magnitude estimates of the amount of particles in the gritty - grainy, chalky - drying and grainy - gummy - mouthcoating treatments. It was intended that the latter two treatments contain the greatest number of particles. These two treatments were consistently found to contain more particles than the gritty - grainy treatment (Table 15). It can be seen in Table 15 that all judges except one and five found fewer particles in the chalky - drying treatment than in the grainy - gummy - mouthcoating treatment. However, it is uncertain whether the difference in the amount of particles between these two treatments is significant.

Figure 10

OVERALL MEAN MAGNITUDE ESTIMATES OF PARTICLE SIZE IN MODEL SYSTEM SAMPLES



*Reference = Puréed Pears

Table 14

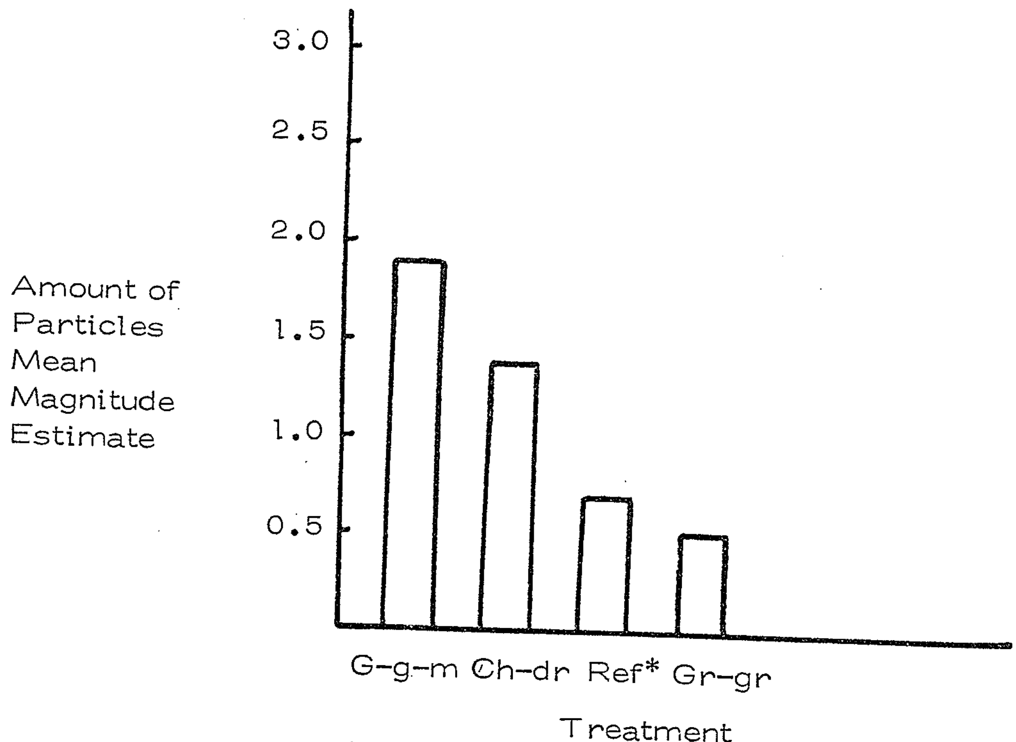
Mean Magnitude Estimates of Particle Size in Treatments by Judge over Replications

Treatment	Particle Size Mean Magnitude Estimate by Judge					
	1	2	3	4	5	6
Reference*	2.25	2.16	1.93	1.50	1.36	2.41
GR - GR	0.45	0.27	0.27	0.55	0.40	0.39
CH - DR	0.41	0.86	0.69	0.87	0.59	0.45
G - G - M	2.42	1.97	2.82	1.40	3.16	2.41

*Reference = Purẽed Pears

Figure 11

OVERALL MEAN MAGNITUDE ESTIMATES OF AMOUNT OF PARTICLES IN MODEL SYSTEM SAMPLES



*Reference = Puréed Pears

Table 15

Mean Magnitude Estimates of Amount of Particles in Treatments by Judge over Replications

Treatment	Amount of Particles Mean Magnitude Estimate by Judge					
	1	2	3	4	5	6
Reference *	1.08	1.00	0.75	0.88	0.33	0.45
GR – GR	0.30	0.43	0.39	0.70	1.11	0.73
CH – DR	1.96	1.37	1.72	0.81	2.18	0.84
G – G – M	1.56	1.69	1.97	2.01	1.27	3.60

*Reference = Puréed Pears

H. Pulpyness

The pulpy treatment was clearly more pulpy than the other three treatments in which this characteristic was found (Figure 12, Table 16). The panel rated the gritty - grainy, chalky - drying and grainy - gummy - mouthcoating treatments as containing small amounts of pulp. These treatments were prepared from the same smooth base as were the two smooth and three taste treatments. They were therefore devoid of pulpyness. The panel evidently confused the particles in the former treatments with the characteristic of pulpyness.

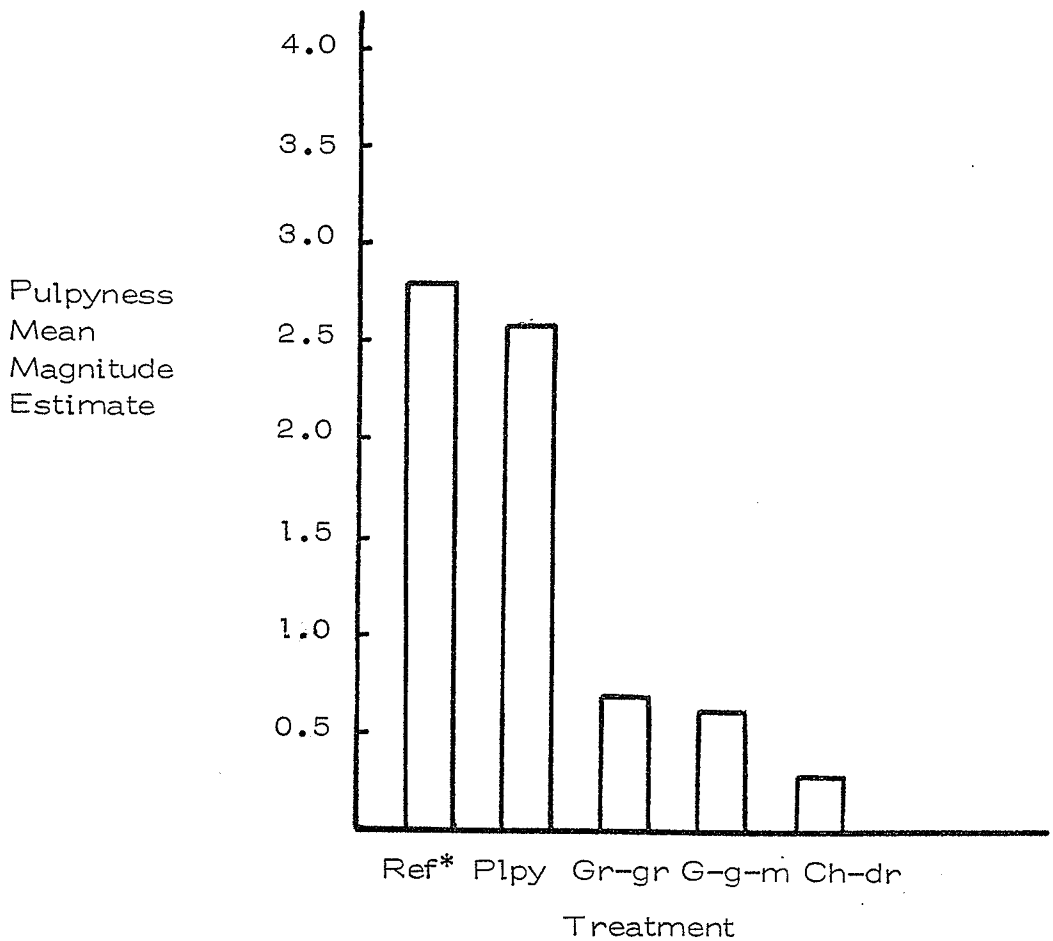
I. Gumminess

The overall mean magnitude estimates of gumminess found in the model system samples are illustrated in Figure 13. Highly significant ($p = 0.001$) treatment by judge and judge by replication interactions were found. This indicates that the judges had difficulty evaluating this characteristic.

Examination of the data in Table 17 reveals no consistently outstanding differences in gumminess between the treatments. The smooth - thick and gritty - grainy treatments may be slightly more gummy than the others. The gumminess estimates for these treatments are among the highest ratings given by at least five of the judges (Table 17). This would be due to the fact that no water

Figure 12

OVERALL MEAN MAGNITUDE ESTIMATES OF PULPYNESS IN MODEL SYSTEM SAMPLES



*Reference = Purééd Carrots

Table 16

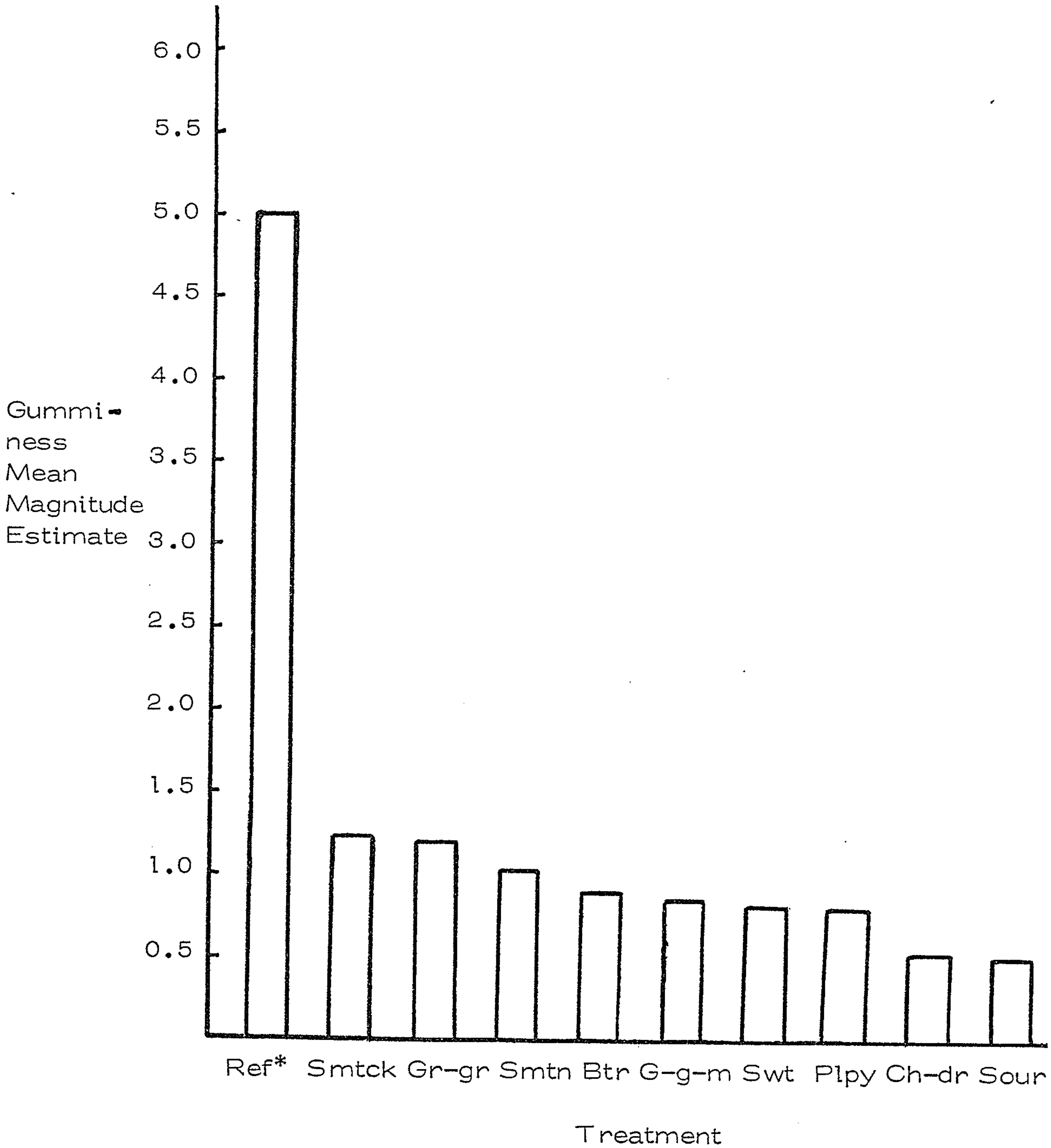
Mean Magnitude Estimates of Pulpyness in Treatments by Judge over Replications

Treatment	Pulpyness Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference*	1.94	2.33	2.29	4.85	3.41	2.87
PLPY	1.63	1.72	2.43	4.85	3.63	2.55
GR - GR	0.70	0.68	1.37	0.45	0.79	0.52
CH - DR	0.49	0.37	0.36	0.21	0.37	0.17
G - G - M	0.91	1.00	0.36	0.45	0.27	1.56

*Reference = Puréed Carrots

Figure 13

OVERALL MEAN MAGNITUDE ESTIMATES OF GUMMINESS IN MODEL SYSTEM SAMPLES



*Reference = Flour Paste

Table 17

Mean Magnitude Estimates of Gumminess in Treatments by Judge over Replications

Treatment	Gumminess Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference*	6.37	3.41	3.95	5.05	4.30	8.55
SWT	1.16	1.24	1.31	0.80	0.29	0.68
SOUR	0.51	0.62	0.69	0.50	0.20	0.68
BTR	0.55	0.54	1.14	0.83	2.61	0.68
SMTCK	1.27	0.96	1.14	1.05	3.62	0.68
SMTN	0.55	0.78	1.58	0.80	2.55	0.84
PLPY	1.07	0.68	0.50	1.01	1.08	0.68
GR - GR	0.94	1.17	1.14	1.16	1.47	1.26
CH - DR	0.55	1.02	0.45	0.64	0.14	1.06
G - G - M	1.27	1.13	0.54	0.92	0.78	0.68

*Reference = Flour Paste

was added in the formulations of these treatments (Table 5). Therefore, the maximum gumminess of the smooth base was not diluted in their preparation. The grainy - gummy - mouthcoating treatment was designed to be more gummy than the other treatments. However, this was not found to be the case (Figure 13, Table 17). The gumminess of the treatments was limited to that obtainable from the basic ingredients for the systems. Additives are not allowed for use in infant foods. Therefore, a chemical agent could not be used to make the treatments more or less gummy. In determining the final formulations for the systems, it was felt that characteristics other than gumminess were more important to optimize in the treatments for the purpose of this investigation.

The reference flour paste was found to be considerably more gummy than any of the treatments (Table 17). A less concentrated flour paste should have been used since this reference may have deflated the gumminess ratings for the treatments and confused the panel. Compared to the highly gummy reference, the gumminess found in the treatments was slight. Similarly to viscosity, the reference flour paste was most likely significantly more gummy than the treatments.

J. Dryness

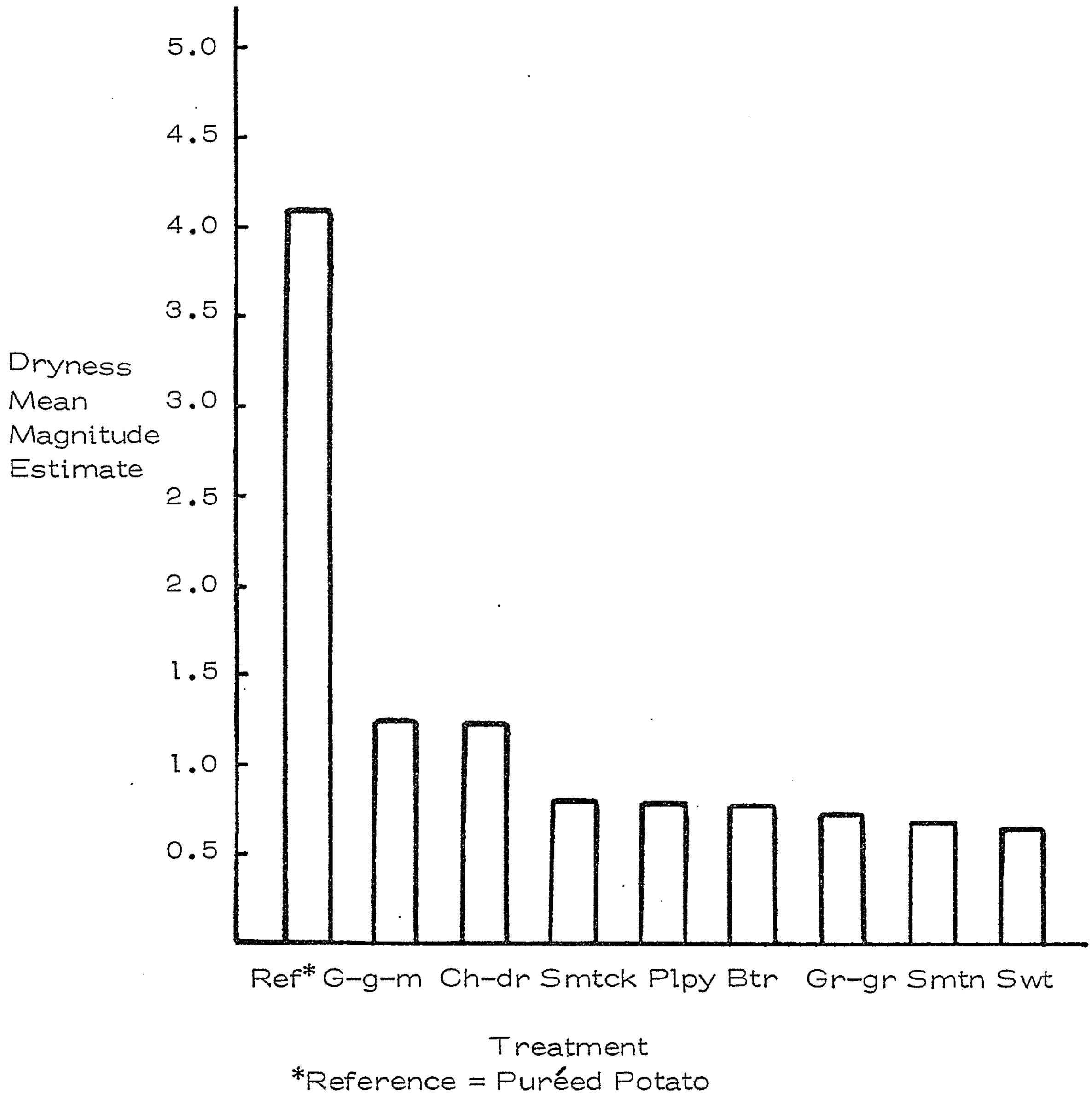
Dryness was not perceived in the sour treatment. The grainy - gummy - mouthcoating and chalky - drying treatments were designed to be drying through the addition of purēed potato. The same purēed potato was used as a reference standard for this characteristic. The reference was more drying than any of the treatments (Figure 14, Table 18). However, it appears from Figure 14 that the grainy - gummy - mouthcoating and chalky - drying treatments were more drying than the others. The dryness ratings for these two treatments were the highest given by one-half of the panelists and among the highest of at least two-thirds of the panel (Table 18).

K. Mouthcoating

Figure 15 shows the overall mean magnitude estimates of mouthcoating in the model system samples. The judges had difficulty evaluating this characteristic as evidenced by the highly significant ($p = 0.001$) judge by treatment interaction found in the analysis. Once again, the reference standard was more mouthcoating than the treatments. The basic ingredients for the systems limited the degree of mouthcoat obtainable in the treatments. There do not appear to be any outstanding differences in the mouthcoat of the treatments (Table 19). However, at least two-thirds of the panelists found the chalky - drying, grainy - gummy - mouthcoating, smooth - thick and gritty - grainy treatments to be more mouthcoating than the others (Table 19). The large number of particles in the former treatments in relation to the others results in slightly more mouthcoat. Some particles would remain on the mouth following swallowing or

Figure 14

OVERALL MEAN MAGNITUDE ESTIMATES OF DRYNESS IN MODEL SYSTEM SAMPLES



*Reference = Puréed Potato

Table 18

Mean Magnitude Estimates of Dryness in Treatments by Judge over Replications

Treatment	Dryness Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference*	3.76	2.21	6.07	5.00	2.82	6.67
SWT	0.75	1.21	0.24	0.63	0.93	0.57
BTR	0.50	1.13	0.81	1.82	0.39	0.72
SMTCK	0.55	0.58	0.35	0.63	2.07	1.95
SMTN	0.41	0.70	0.64	0.50	1.63	0.57
PLPY	0.62	0.58	1.50	0.45	0.97	1.06
GR - GR	0.95	0.82	0.56	1.00	0.42	0.78
CH - DR	2.25	1.25	2.00	1.26	0.70	0.72
G - G - M	2.34	1.37	2.23	0.98	1.04	0.53

*Reference = Puréed Potato

Figure 15

OVERALL MEAN MAGNITUDE ESTIMATES OF MOUTHCOATING IN MODEL SYSTEM SAMPLES

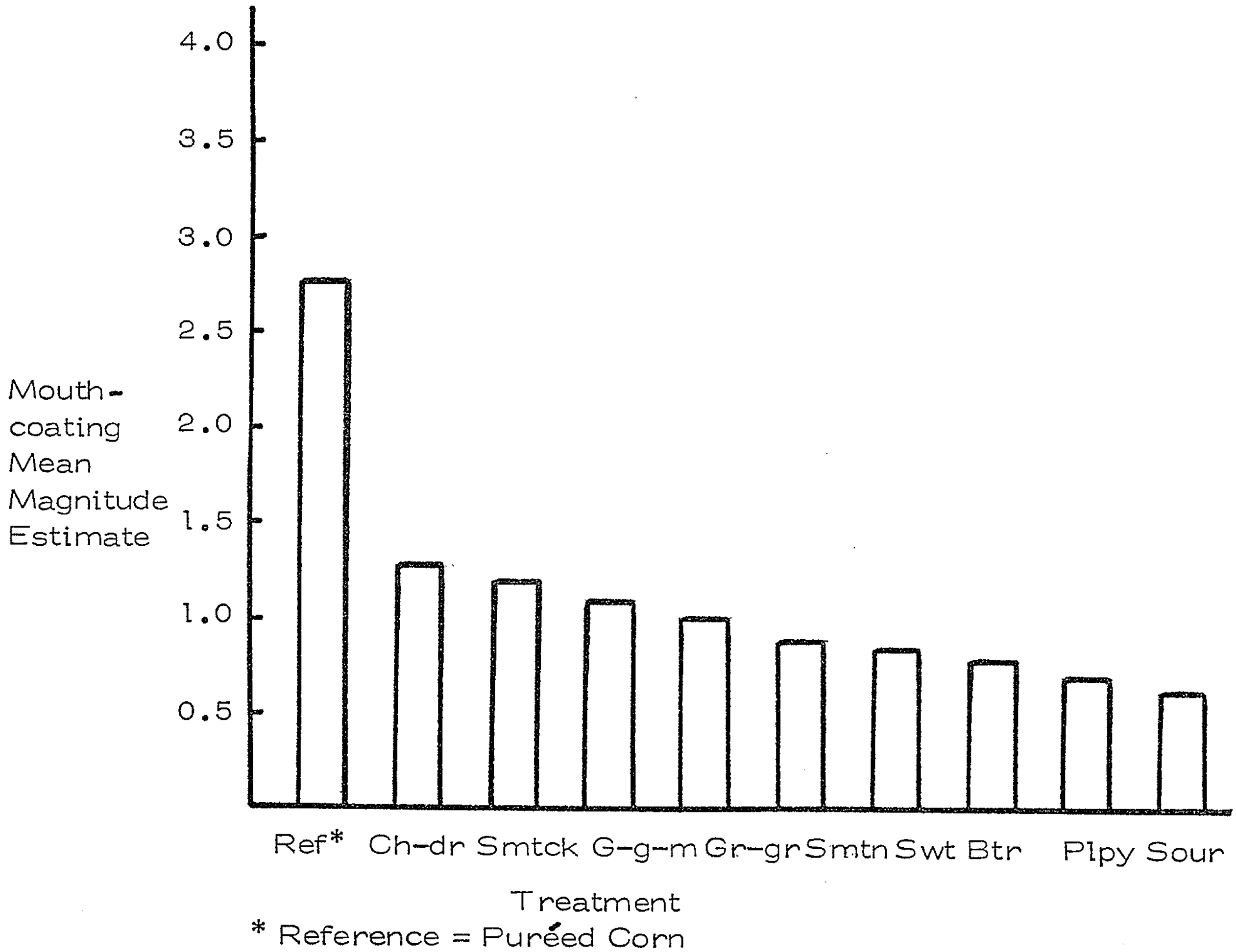


Table 19

Mean Magnitude Estimates of Mouthcoating in Treatments by Judge over Replications

Treatment	Mouthcoating Mean Magnitude Estimate by Judge 1	2	3	4	5	6
Reference*	2.72	2.61	5.08	1.51	4.08	1.97
SWT	1.04	1.63	0.59	0.82	1.30	0.33
SOUR	0.43	0.44	0.63	0.60	0.65	1.09
BTR	0.47	0.60	0.64	0.56	1.83	1.15
SMTCK	0.58	0.95	1.02	1.34	3.13	1.22
SMTN	0.47	0.81	0.44	1.03	1.63	1.56
PLPY	0.99	0.56	0.64	1.08	0.44	0.53
GR - GR	0.93	1.37	0.75	1.19	0.56	1.51
CH - DR	2.79	1.41	1.81	1.27	0.33	1.47
G - G - M	2.50	1.08	2.14	1.38	0.38	0.53

*Reference = Puréed Corn

expectoration. Similarly to gumminess, the latter two treatments may have been slightly more mouthcoating since the smooth base was undiluted in their preparation.

L. Summary of Outstanding Sensory Characteristics in Model System Treatments

The names assigned to each of the model system treatments represented the characteristics in that system which, ideally, were to be outstanding in relation to the other treatments. However, this was not always achieved. The intensities of the sensory characteristics in the nine model systems in relation to each other are summarized in Table 20.

The treatments did not differ greatly in viscosity, gumminess and mouthcoat. The sweet, sour and bitter treatments were found to be outstandingly sweet, sour and bitter respectively in relation to the other treatments. They were also smooth, as were the smooth treatments. The pulpy treatment was found to be obviously pulpy. The gritty - grainy treatment contained a small number of small particles. The chalky - drying treatment contained a large number of small particles while the grainy - gummy - mouthcoating treatment contained a large number of large particles. These latter two treatments were more drying than the others. The taste characteristics of the six texture treatments were minimal and similar.

Table 20

Intensity of the Sensory Characteristics in the Model System Treatments in Relation to the Other Treatments

Sensory Characteristic	Sweetness	Sourness	Bitterness	Viscosity	Particle Size	Amount of Particles	Pulpyness	Gumminess	Dryness	Mouthcoating
Treatment	Intensity	Intensity	Intensity	Intensity	Intensity	Intensity	Intensity	Intensity	Intensity	Intensity
SWT	High	None	None	Avg.*	None	None	None	Avg.	Avg.	Avg.
SOUR	None	High	None	Avg.	None	None	None	Avg.	None	Avg.
BTR	Avg.	Avg.	High	Avg.	None	None	None	Avg.	Avg.	Avg.
SMTCK	Avg.	Avg.	None	Avg.	None	None	None	Avg.	Avg.	Avg.
SMTN	Avg.	Avg.	None	Avg.	None	None	None	Avg.	Avg.	Avg.
PLPY	Avg.	Avg.	None	Avg.	None	None	High	Avg.	Avg.	Avg.
GR - GR	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
CH - DR	Avg.	Avg.	None	Avg.	Avg.	High	Avg.	Avg.	High	Avg.
G - G - M	Avg.	None	None	Avg.	High	High	Avg.	Avg.	High	Avg.

*Avg. = Average

IV VALIDITY OF THE INFANT STUDY MEASURING INSTRUMENT AND FREQUENCY OF FOLLOWING INSTRUCTIONS

Some of the results from the questionnaire (Appendix M) served to validate the five-point hedonic scale used by mothers to record their infant's reactions to the treatments. Mothers were familiarized with the scale prior to the study by using it to indicate their infant's acceptance of various foods. It was found that the mothers' verbal descriptions of their infant's physical reactions to foods closely echoed the written descriptions given for the mothers' specified scale points. This indicates that the scale points were differential and that each mother understood the distinctions between them.

Thirty-one of the forty-nine mothers (63.3%) fed the samples for eighteen consecutive days, as instructed. It is uncertain whether three of the remaining eighteen infants received the samples consecutively due to their mother's failure to consistently record the dates. The samples were not fed consecutively to fifteen subjects either because of illness or their mother's forgetfulness. In five of these cases, only one or two days of feeding were missed.

It should be emphasized that, in presenting the results of this study, any mention of infant acceptance should actually be interpreted as infant acceptance "as perceived by their mother".

V INFANT ACCEPTANCE OF MODEL SYSTEM TREATMENTS

The hypotheses were tested at the five percent level of significance. Probability levels of less than 0.25 and 0.10 are also shown in the tables as they may indicate trends in acceptance. Order of acceptance is indicated by the mean ranks with the highest mean rank representing the greatest acceptance.

A. Overall Acceptance by All Subjects

The mean treatment acceptance scores are found in Table 21.

TEST HYPOTHESIS I: There is no difference in the acceptance of all treatments by all subjects.

The null hypothesis was rejected at less than the 0.001 level of significance (Table 21). It was concluded that there was a highly significant difference in infant acceptance of the treatments. Duncan's Multiple Range Test showed that the sweet treatment was significantly preferred to the bitter, sour, chalky - drying and grainy - gummy - mouthcoating treatments (p = 0.01) (Table 21). It was also preferred to the pulpy and gritty - grainy treatments at the 5% level of significance. Greater acceptance was exhibited for the smooth, pulpy and gritty - grainy treatments than for the grainy - gummy - mouthcoating treatment (p = 0.01). At the 5% level of significance, the bitter treatment was also preferred to the grainy - gummy - mouthcoating treatment. The sour and chalky - drying treatments were found to be significantly less preferred than the smooth treatments (p = 0.05).

Table 21

Acceptance of All Treatments by All Subjects

(N = 49)

Friedman's Analysis of Variance by Ranks

Treatment	Mean Acceptance Score*	Mean Rank	p=0.05**	p=0.01**	Value of Test Statistic***	df	Probability
Sweet	4.07	6.58	a	a	58.12	8	< 0.001
Smooth - Thick	3.79	5.72	ab	ab			
Smooth - Thin	3.77	5.71	ab	ab			
Pulpy	3.60	5.27	bc	ab			
Gritty - Grainy	3.56	5.15	bc	ab			
Bitter	3.43	4.66	bc	bc			
Sour	3.33	4.33	cd	bc			
Chalky - Drying	3.32	4.20	cd	bc			
Grainy - Gummy - Mouthcoating	2.96	3.37	d	c			

*5 = Obviously Likes
4 = Seems to Like
3 = Indifferent
2 = Seems to Dislike
1 = Obviously Dislikes

** Results of Duncan's Multiple Range Test. Treatments with the Same Superscript are not Significantly Different.

*** Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

B. Discussion of Infant Acceptance and the Sensory Characteristics of the Model System Treatments

1. Relationship

Differences in infant acceptance of the model systems should only be due to differences in the sensory characteristics of the treatments. All variations in the sensory characteristics of the treatments stemmed from the smooth base. The slight differences in the sensory characteristics of the smooth treatments did not affect their acceptance. No significant difference in infant acceptance was found between these two treatments. This suggests that only the large differences in the sensory characteristics of the treatments are relevant in relation to infant acceptance.

The treatments were all well accepted by the infants. The mean treatment acceptance scores were generally all on the positive side of the scale. They ranged from 4 representing a "seems to like" reaction to 3 or "indifferent". The sweet treatment received the highest mean acceptance score (and mean rank in the analysis). It was followed closely by the two smooth treatments. No significant difference in acceptance was found between these treatments. Szczesniak (1972) stated that infants prefer the smooth textures of infant foods. The findings of this study serve to validate this author's observation.

The sweet, sour and bitter stimuli were added to the smooth - thin treatment. The textural characteristics of these four treatments were generally the same. However, the taste treatments were outstandingly sweet, sour and bitter respectively in relation to the smooth - thin treatment. Although no significant difference in acceptance was found, the acceptance mean score for the sweet treatment was higher than that for the smooth - thin treatment (Table 21). The sweet stimulus may have positively influenced infant acceptance, although not to a significant degree.

The sour treatment was significantly less preferred than the smooth - thin treatment ($p = 0.05$). This establishes that the five to eight month old infants in this study could taste the sour stimulus and that it adversely influenced their food acceptance.

No significant difference in acceptance was found between the smooth - thin and bitter treatments. However, the bitter treatment was significantly less preferred than the sweet treatment ($p = 0.01$). This suggests that the bitter stimulus had a negative influence on infant acceptance of the treatments.

The lack of significance between the smooth - thin and bitter treatments may have been due to a number of factors. Infants have been reported to have lower taste thresholds than adults (Flasarova, 1959; Kulakowskaja, 1930). In addition, it is well known that adults taste thresholds for bitter compounds are highly variable.

The same may be true of infants. The lack of significance may have been due to an "averaging" effect. The scores of those infants who perceived the bitterness and reacted negatively to it would have been neutralized somewhat by the scores of those infants who were insensitive to the bitter stimulus. Had the sample size been larger, a significant difference between the bitter and smooth – thin treatments may have been attained. No significant difference in acceptance was found between the sour and bitter treatments. Both were significantly less preferred than the sweet treatment ($p = 0.01$).

The texture treatments assessed in this study possessed only minimal sweetness and sourness compared to the sweet and sour treatments. Infant acceptance of the texture treatments is therefore in the context of "acceptance in the absence of outstanding taste characteristics."

The pulpy and gritty – grainy treatments were as highly accepted as the smooth treatments. Pulpyness was the outstanding characteristic of the pulpy treatment. Compared to the smooth treatments, the gritty – grainy treatment contained a small number of small particles. Therefore, in addition to smoothness, infants seem to accept pulpy textured foods and those containing a few small particles.

The chalky – drying treatment was significantly less preferred than the smooth treatments ($p = 0.05$). The grainy – gummy – mouthcoating treatment was significantly less preferred than the smooth, pulpy and gritty – grainy treatments ($p = 0.01$). The chalky –

drying treatment contained a larger number of slightly larger particles than the gritty - grainy treatment. The latter treatment was not accepted differently from the smooth treatments whereas the former was (p = 0.05). This suggests that infant acceptance may decrease with an increase in the number of particles in foods. The grainy - gummy - mouthcoating treatment contained larger particles in greater numbers than either the gritty - grainy or chalky - drying treatments. It was significantly less preferred to both the smooth and gritty - grainy treatments (p = 0.01). This would further indicate that as the size and number of particles in a food increases, infant acceptance decreases. Both the chalky - drying and grainy - gummy - mouthcoating treatments were found to be more drying than the others. Therefore, dryness may also adversely affect infant food acceptance.

2. Implications

Strained fruits for infants are sweet and frequently smooth. Infants were found to exhibit significantly greater preferences (p=0.05) for both of these characteristics over other sensory characteristics which they encounter in their food. This at least partially explains why fruits are such a well accepted food group by infants.

Pulpyness is commonly encountered in puréed vegetables. Vegetables are less popular with infants than fruits. However, the pulpy treatment was as well accepted as the smooth treatments in this study. Therefore, pulpyness is probably not solely responsible for the unpopularity of vegetables. Vegetables are frequently more sour than fruits. Sourness at a level infants encounter in their food was found to significantly decrease food acceptance ($p = 0.05$). This suggests that this taste characteristic may contribute to low vegetable acceptance by infants. Bitterness may also play a role in vegetable acceptance. The bitter stimulus used in this study appeared to negatively influence infant food acceptance.

The grainy - gummy - mouthcoating treatment was designed to be dry and to contain numerous large particles simulating the texture of strained meat products. This treatment was the least preferred by the infants in this study. Therefore, the problems associated with meat introduction to infants may be due to its complex texture. In agreement with Szczesniak (1972), the texture of meat most likely makes it difficult for infants to control in the mouth. Oral function is very restricted in infants before ten months of age due to the absence of lateral chewing movements. This would also account for decreased infant acceptance with increasing size and number of particles in a food. Control of food in the mouth most likely becomes increasingly difficult as the smoothness of a product decreases.

C. Effect of Age on Acceptance of Treatments

The subjects were divided into three age groups (Table 7). AGE 1 consisted of sixteen infants six months of age or younger, AGE 2 contained eighteen infants between six and seven months of age and AGE 3 was composed of fifteen infants over seven months of age. Table 22 contains the mean treatment acceptance scores by age group.

TEST HYPOTHESIS II: There is no difference in the acceptance of all treatments between the three age groups.

As can be seen in Table 22.1, the null hypothesis was accepted ($p = 0.05$). It was concluded that age did not affect infant acceptance of the treatments.

Harasym (1977) found that older infants tended to be more discriminating in their vegetable preferences than younger infants. The infants in this author's study ranged in age from six to nineteen weeks and the background feeding experiences of the subjects varied. In the present study, the vast majority of the subjects were between five and eight months of age and the background feeding experiences of all subjects were similar. Perhaps the narrower age span of the subjects than those investigated by Harasym (1977) accounted for the absence of an age effect on infant acceptance of the treatments. Alternatively, perhaps after infants are on a full range of semi-solids, they can be considered as a uniform sample regardless of their age differences.

Table 22

Mean Acceptance Scores for All Treatments by Age Group
(N=49)

Treatment	Mean Acceptance Score*		
	Age 1 (≤ 6 months) n = 16	Age 2 (> 6 ≤ 7 months) n = 18	Age 3 (> 7 months) n = 15
SWT	4.06	4.14	4.00
SOUR	3.50	3.25	3.23
BTR	3.53	3.58	3.13
SMTCK	3.81	3.81	3.73
SMTN	3.78	3.94	3.53
PLPY	3.97	3.58	3.23
GR - GR	3.72	3.61	3.33
CH - DR	3.69	3.17	3.10
G - G - M	2.84	3.22	2.77

* 5 = Obviously Likes
4 = Seems to Like
3 = Indifferent
2 = Seems to Dislike
1 = Obviously Dislikes

Table 22.1

Acceptance of All Treatments by Age Group
(N = 49)

Kruskal - Wallis Analysis of Variance by Ranks

Treatment	Age Group	n	Mean Rank	Value of Test Statistic*	df	Probability
SWT	1	16	24.97	0.513	2	n.s.
	2	18	26.58			
	3	15	23.13			
SOUR	1	16	27.03	0.527	2	n.s.
	2	18	24.36			
	3	15	23.60			
BTR	1	16	26.28	1.542	2	n.s.
	2	18	26.97			
	3	15	21.27			
SMTCK	1	16	25.28	0.054	2	n.s.
	2	18	25.33			
	3	15	24.30			
SMTN	1	16	25.66	2.139	2	n.s.
	2	18	27.83			
	3	15	20.90			
PLPY	1	16	30.28	4.394	2	n.s. (< 0.25)
	2	18	24.69			
	3	15	19.73			
GR - GR	1	16	26.09	0.586	2	n.s.
	2	18	25.94			
	3	15	22.70			
CH - DR	1	16	30.50	3.670	2	n.s. (< 0.25)
	2	18	22.53			
	3	15	22.10			
G - G - M	1	16	23.44	2.794	2	n.s. (< 0.25)
	2	18	29.28			
	3	15	21.53			

*Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

D. Effect of Order of Fruit and Vegetable Introduction on Acceptance of Treatments

The subjects were divided into two groups according to the order in which fruit and vegetables were introduced into their diets (Table 9.2). Thirty - nine infants who were introduced to fruit before or simultaneously with vegetables made up the Fruit 1 (=2) group. The Fruit 2 group consisted of ten subjects who received vegetables prior to the introduction of fruit.

The purpose of the analysis was to investigate whether exposing infants to the sweetness and predominantly smooth texture of puréed fruit before they received the less sweet, more pulpy textured vegetables would affect their acceptance of the treatments. Since infants simultaneously introduced to fruit and vegetables would receive an equal amount of exposure to the sensory characteristics of fruit as if fruit were introduced first, these subjects were grouped together. The mean treatment acceptance scores of the two groups are found in Table 23.

TEST HYPOTHESIS III : There is no difference in the acceptance of all treatments between infants introduced to fruit before or simultaneously with vegetables and infants fed vegetables first.

As can be seen in Table 23.1, the null hypothesis was accepted ($p = 0.05$).

Although no significant differences in infant acceptance of the treatments were found, two trends of interest were revealed in the analysis. Infants introduced to fruit before or simultaneously with

Table 23

Mean Acceptance Scores for All Treatments by Order of Fruit and Vegetable Introduction

(N = 49)

Treatment	Mean Acceptance Score*	
	Fruit 1 (= 2) (fed fruit first or simultaneously with vegetables) n = 39	Fruit 2 (fed vegetables first) n = 10
SWT	4.19	3.60
SOUR	3.33	3.30
BTR	3.45	3.35
SMTCK	3.79	3.75
SMTN	3.74	3.85
PLPY	3.50	4.00
GR – GR	3.60	3.40
CH – DR	3.27	3.50
G – G – M	2.92	3.10

* 5 = Obviously Likes
4 = Seems to Like
3 = Indifferent
2 = Seems to Dislike
1 = Obviously Dislikes

Table 23.1

Acceptance of All Treatments by Order of Fruit and Vegetable Introduction

(N = 49)

Kruskal - Wallis Analysis of Variance by Ranks

Treatment	Fruit Group	n	Mean Rank	Value of Test Statistic*	df	Probability
SWT	1 (=2) 2	39 10	26.86 17.75	3.478	1	n.s. (< 0.10)
SOUR	1 (=2) 2	39 10	25.14 24.45	0.019	1	n.s
BTR	1 (=2) 2	39 10	25.27 23.95	0.070	1	n.s
SMTCK	1 (=2) 2	39 10	25.09 24.65	0.008	1	n.s.
SMTN	1 (=2) 2	39 10	24.37 27.45	0.400	1	n.s.
PLPY	1 (=2) 2	39 10	23.56 30.60	2.004	1	n.s. (< 0.25)
GR - GR	1 (=2) 2	39 10	25.64 22.50	0.402	1	n.s.
CH - DR	1 (=2) 2	39 10	24.19 28 .15	0.635	1	n.s.
G - G - M	1 (=2) 2	39 10	24.33 27.60	0.432	1	n.s.

*Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

vegetables tended to prefer the sweet treatment more than infants introduced to vegetables first (Table 23.1). This finding was approaching significance at the 5% level. This would indicate that exposing an infant to the sweetness of fruit before the less sweet vegetables may reinforce the sweet preference. This could adversely affect vegetable acceptance. Harasym (1977) found that infants introduced to vegetables before fruit exhibited significantly greater preferences for frozen vegetables than infants fed fruit first ($p = 0.05$). Vegetables may be less popular than fruit with infants since fruits are usually introduced first.

In addition, infants introduced to vegetables first appeared to react more favorably to the pulpy treatment ($p < 0.25$). Pulpyness is a common characteristic in puréed vegetables. This would further indicate that introduction of vegetables before fruit may result in higher vegetable acceptance by infants.

The relationship between food preferences in infancy and those later in life is unknown. These results suggest that feeding practices in infancy may influence infant food preferences. It is possible that the food preferences established in infancy persist into later years.

E. Effect of Age of First Introduction to Semi-Solids on Acceptance of Treatments

The subjects were divided into three groups (Table 9.1). The INTRO 1 group contained fifteen infants who were introduced to solids at less than two months of age. Eighteen subjects who had regularly received semi - solids between two and four months of age made up the INTRO 2 group. The INTRO 3 group consisted of sixteen infants whose age of first introduction to semi - solids was between four and six months.

TEST HYPOTHESIS IV : The age of first introduction to semi - solids does not affect the acceptance of all treatments.

The mean treatment acceptance scores for the three groups are found in Table 24. The null hypothesis was accepted (p = 0.05) (Table 24.1).

F. Effect of Number of Months on Semi - Solids on Acceptance of Treatments

Because the ages of the subjects varied, they were divided into four groups based on the number of months they had received semi - solids prior to the study (Table 9.3). Ten infants who had been on semi - solids for less than three months constituted the FED 1 group. The FED 2 group consisted of seventeen infants receiving solids for between three and four months and the FED 3 group contained thirteen infants who were fed solids for between four and five months. Nine subjects who had received semi - solids for five months or more made up the FED 4 group. The mean treatment acceptance scores by number of months on semi - solids can be seen in Table 25.

TEST HYPOTHESIS V : The number of months on semi - solids does not affect the acceptance of all treatments.

The null hypothesis was accepted (p = 0.05) as can be seen in Table 25.1.

Table 24

Mean Acceptance Scores for All Treatments by Age of First Introduction to Semi - Solids

(N = 49)

Treatment	Mean Acceptance Score* Intro 1 (≤ 2 months) n = 15	Intro 2 (2 ≤ 4 months) n = 18	Intro 3 (4 < 6 months) n = 16
SWT	4.33	3.97	3.94
SOUR	3.07	3.61	3.25
BTR	3.50	3.56	3.22
SMTCK	4.10	3.94	3.31
SMTN	3.73	3.86	3.69
PLPY	3.57	3.78	3.44
GR - GR	4.13	3.25	3.38
CH - DR	3.27	3.44	3.22
G - G - M	2.87	3.19	2.78

* 5 = Obviously Likes
4 = Seems to Like
3 = Indifferent
2 = Seems to Dislike
1 = Obviously Dislikes

Table 24.1

Acceptance of All Treatments by Age of First Introduction to Semi - Solids

(N = 49)

Kruskal - Wallis Analysis of Variance by Ranks

Treatment	Intro Group	n	Mean Rank	Value of Test Statistic*	df	Probability
SWT	1	15	28.40	1.496	2	n.s.
	2	18	22.56			
	3	16	24.56			
SOUR	1	15	21.27	2.990	2	n.s. (< 0.25)
	2	18	29.36			
	3	16	23.59			
BTR	1	15	26.23	1.018	2	n.s.
	2	18	26.56			
	3	16	22.09			
SMTCK	1	15	29.53	5.372	2	n.s. (< 0.10)
	2	18	27.00			
	3	16	18.50			
SMTN	1	15	24.10	0.181	2	n.s.
	2	18	26.06			
	3	16	24.66			
PLPY	1	15	24.10	1.552	2	n.s.
	2	18	28.14			
	3	16	22.31			
GR - GR	1	15	32.27	5.966	2	n.s. (< 0.10)
	2	18	21.00			
	3	16	22.69			
CH - DR	1	15	24.77	0.275	2	n.s.
	2	18	26.28			
	3	16	23.78			
G - G - M	1	15	23.57	1.396	2	n.s.
	2	18	28.08			
	3	16	22.88			

* Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

Table 25

Mean Acceptance Scores for All Treatments by Number of Months on Semi - Solids

(N = 49)

Treatment	Mean Acceptance Score*			
	Fed 1 (< 3 months) n = 10	Fed 2 (3 < 4 months) n = 17	Fed 3 (4 < 5 months) n = 13	Fed 4 (≥ 5 months) n = 9
SWT	3.45	4.38	4.04	4.22
SOUR	3.40	3.41	3.38	3.00
BTR	3.35	3.26	3.50	3.72
SMTCK	3.15	3.97	3.88	4.00
SMTN	3.65	3.79	3.85	3.72
PLPY	3.75	3.65	3.69	3.22
GR - GR	3.10	3.44	3.69	4.11
CH - DR	3.20	3.35	3.62	2.94
G - G - M	2.70	3.12	2.96	2.94

* 5 = Obviously Likes
4 = Seems to Like
3 = Indifferent
2 = Seems to Dislike
1 = Obviously Dislikes

Table 25.1

Acceptance of All Treatments by Number of Months on Semi - Solids

(N = 49)

Kruskal - Wallis Analysis of Variance by Ranks

Treatment	Fed Group	n	Mean Rank	Value of Test Statistic*	df	Probability
SWT	1	10	16.95	6.480	3	n.s. (< 0.10)
	2	17	30.59			
	3	13	23.19			
	4	9	26.00			
SOUR	1	10	26.25	0.810	3	n.s.
	2	17	25.97			
	3	13	25.35			
	4	9	21.28			
BTR	1	10	24.10	1.550	3	n.s.
	2	17	22.56			
	3	13	25.69			
	4	9	29.61			
SMTCK	1	10	15.90	5.413	3	n.s. (< 0.25)
	2	17	27.68			
	3	13	26.27			
	4	9	28.22			
SMTN	1	10	24.90	0.030	3	n.s.
	2	17	25.00			
	3	13	25.46			
	4	9	24.44			
PLPY	1	10	27.20	1.962	3	n.s.
	2	17	26.00			
	3	13	26.04			
	4	9	19.17			

*Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

continued

Table 25.1 continued

Treatment	Fed Group	n	Mean Rank	Value of Test Statistic*	df	Probability
GR - GR	1	10	18.15	5.510	3	n.s. (< 0.25)
	2	17	23.06			
	3	13	28.08			
	4	9	31.83			
CH - DR	1	10	23.80	1.953	3	n.s.
	2	17	24.94			
	3	13	28.96			
	4	9	20.72			
G - G - M	1	10	21.95	0.740	3	n.s.
	2	17	26.74			
	3	13	25.23			
	4	9	24.78			

*Corrected for ties. For large sample sizes, the test statistic approximately follows a Chi-Square distribution.

No significant differences in infant acceptance of the treatments were found due to the age of first introduction to semi - solids or the number of months the subjects had been on semi - solids prior to the study. This would further suggest that once infants are receiving a full range of non - milk foods, they can be considered as a uniform sample.

SUMMARY AND CONCLUSIONS

Heinz puréed fruit, vegetable and meat products were evaluated by an experienced sensory panel to determine their taste and textural characteristics. Based on the results of these analyses, six textural systems were developed to copy the range of textures found in Heinz strained infant foods. These were: 1) smooth - thick, 2) smooth - thin, 3) pulpy, 4) gritty - grainy, 5) chalky - drying and 6) grainy - gummy - mouthcoating. The names assigned to the six texture treatments represented the textural characteristics which, ideally, were to be predominant in that treatment in relation to the others. The six texture treatments were reproduced in bland model systems prepared from commercially canned applesauce, Bartlett pears and whole white potatoes. A trained sensory panel assisted in the development of the systems. The panel also established the maximum perceived intensities of sweetness, sourness and bitterness found in Heinz infant foods in terms of their corresponding percent sucrose, citric acid and caffeine concentrations respectively. These taste intensities were represented in the smooth - thin texture treatment, respectively creating a sweet, sour and bitter treatment for study.

A trained sensory panel assessed the nine model system treatments for three taste and seven textural characteristics. The treatments did not differ greatly in viscosity, gumminess and mouthcoat. The sweet, sour and bitter treatments were found to be obviously sweet, sour and bitter respectively in relation to the other treatments. They were also smooth, as were the smooth treatments. The pulpy treatment was found to be outstandingly pulpy. The gritty - grainy treatment contained a small number of small particles. The chalky - drying and grainy - gummy - mouthcoating treatments were found to be more drying than the other treatments. The chalky - drying treatment contained a large number of small particles while the grainy - gummy - mouthcoating treatment contained a large number of large particles. The taste characteristics of the six texture treatments were similar and minimal.

Forty - nine infants between four and nine and one-half months of age took part in an eighteen day study to determine infant acceptance of the nine model systems. The mothers of the subjects observed and recorded their infant's reaction to each treatment on a five-point hedonic scale. The scale points ranged from "obviously likes" to "obviously dislikes."

Infants exhibited the greatest acceptance for the sweet and both of the smooth treatments ($p = 0.05$). This finding at least partially explains why fruits are such a well accepted food group by infants. Sourness adversely affected food acceptance ($p = 0.05$) and bitterness tended to exert a negative influence on infant acceptance. Both of these taste characteristics may play a role in the unpopularity of vegetables among infants. The pulpy and gritty - grainy treatments were as highly accepted as the smooth treatments. Therefore, in addition to smoothness, infants seem to accept pulpy textured foods and those containing a few small particles. The chalky - drying and grainy - gummy - mouthcoating treatments were significantly less preferred than the smooth ($p = 0.05$) and the smooth, pulpy and gritty - grainy treatments ($p = 0.01$) respectively. It appears that as the size and number of particles in a food increases, infant acceptance decreases. The problems associated with meat introduction to infants may be attributable to the numerous large particles in purēed meat. Since the chalky - drying and grainy - gummy - mouthcoating treatments were more drying than the others, dryness may also adversely affect infant food acceptance.

The effects of selected background feeding practices on infant acceptance of the model systems were investigated. The subjects who had been introduced to the sweetness of fruit before or simultaneously with the less sweet vegetables tended to prefer the sweet treatment more than infants fed vegetables first. Infants fed vegetables before fruit tended to exhibit greater preferences for the pulpy treatment. Pulpyness is commonly encountered in purēed vegetables. Introduction of fruits before vegetables may negatively affect infant vegetable acceptance. This trend supports the recommendation of the Manitoba Department of Health and Social Development (1976) that vegetables be introduced before fruit to encourage vegetable acceptance. No significant differences in infant acceptance of the treatments ($p = 0.05$) were found due to the age of the subjects, the age at which they were first introduced to semi-solids or the number of months they had been fed semi-solids prior to the study. All subjects were receiving a full range of non-milk foods including juice, cereal, fruit, vegetables and meat at the time of the study. This suggests that once infants are introduced to all types of semi-solids, they can be considered as a uniform sample, regardless of age differences. This finding has implications for the design of future infant feeding studies.

The results of this study clearly establish that infants less than ten months of age do exhibit food preferences and that these preferences are significantly related to the taste and textural characteristics of a food. In addition, infant food preferences may be influenced by the order in which fruit and vegetables are introduced into their diet. The relationship between food preferences in infancy and those in later years is unknown. However, it is possible that food preferences established in infancy form the basis of food habits which persist throughout life.

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APPENDICES

APPENDIX A

SPECIFICATIONS OF PRODUCTS USED TO CREATE THE MODEL SYSTEMS

Product	Brand	Grade	Specifications	Case Lot
Apple-sauce	Berryland Farm	Canada Fancy	- without sugar added - 398 ml cans, Berryland Canning Company Limited, Haney, B.C.	HOEX X5DS HOEX X6DS
Bartlett Pears	Berryland Farm	Canada Fancy	- water pack - 398 ml cans Berryland Canning Company Limited Haney, B.C.	HIXSB Y4AH
Potatoes	Aylmer	Canada Fancy	- whole white - 540 ml cans Canadian Canners Limited, Hamilton, Ontario	ZFPWS 7127A

APPENDIX B

Preparation Procedures* for Smooth and Pulpy Applesauce Bases, Purēed Pears and Potatoes and Liquified Potatoes

A. Smooth Base

Step 1. Blend applesauce with 100 ml water in a Waring commercial blender on "high" for 60 seconds.
Step 2. Place purēe in a strainer lined with muslin.
Step 3. Wash with 500 ml hot water.
Step 4. Let drain, stirring periodically.
Step 5. Combine all processed product at the end of each day.
Step 6. Extract three uniform random samples, weigh and freeze at -20°C.
Step 7. Package base in air tight containers, weigh and freeze at -20°C.
Step 8. Once frozen, freeze-dry random samples, reweigh and calculate % moisture.

Application: All treatments except pulpy.

B. Pulpy Base

Step 1. Using a pestle, force applesauce through a metal strainer (36 divisions/cm^2).
Step 2. Discard the fiber remaining in the strainer.
Step 3. Place the pulpy drippings in a strainer lined with muslin.
Step 4. Repeat steps 3 to 8 for preparation of smooth base (A).

Application: Pulpy treatment.

C. Purēed Pears

Step 1. Drain product.
Step 2. Wash with 500 ml hot water.
Step 3. Blend pears with 100 ml water in an Imperial kitchen blender on "purēe" for 15 seconds.
Step 4. Repeat steps 2 to 5 for preparation of smooth base (A).
Step 5. Package in air tight containers, weigh and freeze at -20°C.
Step 6. Once frozen, freeze-dry, reweigh and calculate % moisture for processed product.
Step 7. Crush into powder form and transfer to air tight jars for storage at -20°C.

Application: Gritty - grainy treatment.

*Based on one can of product.

APPENDIX B cont'd

D. Puréed Potatoes

Step 1. Repeat steps 1 and 2 for preparation of puréed pears (C).
Step 2. Blend potatoes with 300 ml water in an Imperial kitchen blender on "purée" for 30 seconds.
Step 3. Repeat steps 4 to 7 for preparation of puréed pears (C).

Application: Grainy - gummy - mouthcoating treatment.

E. Liquified Potatoes

Step 1. Repeat steps 1 and 2 for preparation of puréed pears (C).
Step 2. Blend potatoes with 500 ml water in an Imperial kitchen blender on "liquify" for 60 seconds.
Step 3. Repeat steps 4 to 7 for preparation of puréed pears (C).

Application: Chalky - drying treatment.

APPENDIX C

PERCENT MOISTURE* AND SOLIDS** CONTENTS OF THE BASIC INGREDIENTS USED TO PREPARE THE FINAL SAMPLES

A. Smooth Base

Date	Sample	Sample Weight (g) (Before Drying)	Sample Weight (g) (After Drying)	% Moisture	% Solids
Nov. 9/77	1	103.3	5.40	94.77	5.23
	2	100.7	5.76	94.28	5.72
	3	101.5	5.29	94.79	5.21
Nov. 10/77	4	101.5	5.39	94.69	5.31
	5	102.1	5.45	94.66	5.34
	6	106.2	5.62	94.71	5.29
Dec. 20/77	7	99.6	4.69	95.29	4.71
	8	99.9	4.65	95.35	4.65
	9	98.7	4.63	95.31	4.69
Feb. 7/78	10	102.1	5.70	94.42	5.58
	11	101.5	5.60	94.48	5.52
	12	101.6	5.25	94.83	5.17
Feb. 8/78	13	101.8	5.49	94.61	5.39
	14	102.3	5.45	94.67	5.33
	15	102.6	6.22	93.94	6.06
				$\bar{X}$=94.72	$\bar{X}$=5.28

$$\text{*\% Moisture} = \frac{\underset{\text{(Before Drying)}}{\text{Sample Weight (g)}} - \underset{\text{(After Drying)}}{\text{Sample Weight (g)}}}{\text{Sample Weight (g) Before Drying}} \times 100\%$$

** % Solids = 100% - % Moisture

APPENDIX C cont'd

B. Pulpy Base

Date	Sample	Sample Weight (g) (Before Drying)	Sample Weight (g) (After Drying)	% Moisture	% Solids
Dec. 14/77	1	100.0	6.02	93.98	6.02
	2	102.6	6.92	93.26	6.74
	3	100.7	6.90	93.15	6.85
				$\bar{X}$=93.46	$\bar{X}$=6.54

C. Pureed Pears

Date	Sample	Sample Weight (g) (Before Drying)	Sample Weight (g) (After Drying)	% Moisture	% Solids
Nov. 9/77	1	190.0	9.06	95.23	4.77
	2	207.7	10.07	95.15	4.85
	3	205.9	9.85	95.22	4.78
	4	203.6	9.67	95.25	4.75
	5	207.0	10.00	95.17	4.83
	6	209.3	9.78	95.33	4.67
	7	208.5	9.95	95.23	4.77
	8	208.7	10.00	95.21	4.79
	9	200.9	9.30	95.37	4.63
	10	206.9	10.03	95.15	4.85
	11	204.2	9.97	95.12	4.88
	12	200.2	9.66	95.17	4.83
	13	204.4	9.67	95.27	4.73
	14	208.2	10.03	95.18	4.82
				$\bar{X}$=95.22	$\bar{X}$=4.78

APPENDIX C cont'd

D. Purēed Potatoes

Date	Sample	Sample Weight (g) (Before Drying)	Sample Weight (g) (After Drying)	% Moisture	% Solids
Dec. 15/77	1	373.7	34.90	90.66	9.34
	2	325.3	28.22	91.32	8.68
	3	353.5	33.56	90.51	9.49
	4	336.2	32.03	90.47	9.53
	5	295.6	29.94	89.87	10.13
	6	321.8	29.81	90.74	9.26
	7	332.7	32.71	90.17	9.83
	8	370.7	36.79	90.08	9.92
	9	337.6	34.11	89.90	10.10
	10	335.5	34.47	89.73	10.27
	11	336.9	35.16	89.56	10.44
	12	345.8	37.08	89.28	10.72
	13	365.0	38.03	89.58	10.42
	14	367.8	38.31	89.58	10.42
	15	377.2	32.82	91.30	8.70
	16	347.9	31.23	91.02	8.98
	17	352.8	31.66	91.03	8.97
				$\bar{X}$=90.28	$\bar{X}$=9.72

APPENDIX C cont'd

E. Liquified Potatoes

Date	Sample	Sample Weight (g) (Before Drying)	Sample Weight (g) (After Drying)	% Moisture	% Solids
Dec. 19/77	1	341.5	24.15	92.93	7.07
	2	442.8	31.56	92.87	7.13
	3	364.5	26.48	92.74	7.26
	4	411.3	30.07	92.69	7.31
	5	245.6	20.31	91.73	8.27
	6	392.6	32.75	91.66	8.34
	7	246.4	21.20	91.40	8.60
	8	242.4	20.98	91.34	8.66
	9	232.1	20.15	91.32	8.68
	10	239.1	21.37	91.06	8.94
	11	239.5	18.76	92.17	7.83
	12	231.6	19.02	91.79	8.21
	13	228.7	18.73	91.81	8.19
	14	244.5	20.24	91.72	8.28
	15	252.2	20.15	92.01	7.99
	16	226.0	17.88	92.09	7.91
	17	247.3	19.76	92.01	7.99
	18	269.5	23.34	91.34	8.66
				$\bar{X}$=91.93	$\bar{X}$=8.07

APPENDIX D

BALLOT USED IN TASTE TRAINING SESSION

Name: ______________________

Date: ______________________

SWEETNESS: A taste sensation which develops rapidly and is best perceived on the tip of the tongue.

SOURNESS: A taste sensation which develops less rapidly than sweetness but more rapidly than bitterness and is best perceived on the sides of the tongue.

BITTERNESS: A taste sensation which develops slowly and is best perceived at the back of the tongue - may not be perceived until after swallowing.

Please evaluate the sweetness, sourness and bitterness of the samples against their respective references using magnitude estimation.

Taste Sensation	Magnitude Estimate			
		Code Number		
	Reference	______	______	______
SWEETNESS	______	______	______	______
SOURNESS	______	______	______	______
BITTERNESS	______	______	______	______

APPENDIX E

BALLOT USED IN POWER FUNCTION DETERMINATIONS

Name: ____________________

Date: ____________________

Please evaluate the sweetness, sourness or bitterness of the coded samples against their respective references using magnitude estimation. Rinse mouth between samples with water and eat a cracker. Please rest between sets.

SAMPLE	MAGNITUDE ESTIMATE
R1	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
R2	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
R3	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
R4	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________

APPENDIX F

BALLOT USED IN PRIMARY TRAINED PANEL EVALUATION

Name:____________________

Date:____________________

Please evaluate the taste and textural characteristics of the samples against the reference standards, using magnitude estimation. All of the various taste and texture parameters WILL NOT be found in each sample. If a taste or textural characteristic is not found in a sample, use NP for not present. Please evaluate the samples using in and out movements of the tongue only. REMEMBER, babies don't have teeth! Please STIR all samples before tasting. RINSE between samples.

SWEETNESS: A taste sensation which develops rapidly and is best perceived on the tip of the tongue.

Reference: R_1

Sample	Magnitude Estimate
R	

SOURNESS: A taste sensation which develops less rapidly than sweetness, but more rapidly than bitterness and is best perceived on the sides of the tongue.

Reference: R_2

Sample	Magnitude Estimate
R	

APPENDIX F cont'd

BITTERNESS: A taste sensation which develops slowly and is best perceived at the back of the tongue - may not be perceived until after swallowing.

Reference: R_3

Sample	Magnitude Estimate
R	__________
______	__________
______	__________
______	__________
______	__________

VISCOSITY: The force required to suck the sample between the tongue and the palate.

Reference: Diluted Sweetened Condensed Milk.

Sample	Magnitude Estimate
R	__________
______	__________
______	__________
______	__________
______	__________

PARTICLE SIZE: The presence of distinct, regularly shaped particles in the sample which increase in SIZE from chalky to gritty and grainy.

Smooth = NP for this parameter
- absence of distinct particles

Reference: Puréed Pears (Canned)

Sample	Magnitude Estimate
R	__________
______	__________
______	__________
______	__________
______	__________

APPENDIX F cont'd

AMOUNT OF PARTICLES: The NUMBER of distinct, regularly shaped particles in the sample.

Reference: Puréed Pears (Canned)

Sample	Magnitude Estimate
R	

PULPYNESS: The AMOUNT of distinct, irregularly shaped (soft) particles in the sample.

Reference: Puréed Carrots (Canned)

Sample	Magnitude Estimate
R	

GUMMINESS: The tendency of a sample to remain intact - evaluate by rolling sample between the tongue and roof of the mouth.

Reference: Flour paste.

Sample	Magnitude Estimate
R	

APPENDIX F cont'd

DRYNESS: Sample produces the sensation of removing moisture from the mouth - the extent to which sample removes moisture from the mouth.

Reference: Purèed Potato (Canned)

Sample	Magnitude Estimate
R	______
______	______
______	______
______	______
______	______

MOUTHCOATING: A film of sample which remains on (clings to) the tongue and/or palate following swallowing or expectoration.

Reference: Purèed Corn (Frozen)

Sample	Magnitude Estimate
R	______
______	______
______	______
______	______
______	______

APPENDIX G

RANDOMIZED FEEDING ORDER FOR SUBJECT 16

Day of Study	Treatment
1 & 2	Chalky - Drying
3 & 4	Sour
5 & 6	Smooth - Thick
7 & 8	Pulpy
9 & 10	Bitter
11 & 12	Smooth - Thin
13 & 14	Grainy - Gummy - Mouthcoating
15 & 16	Sweet
17 & 18	Gritty - Grainy

APPENDIX H

FREQUENCY DISTRIBUTION of SCORE CHANGES in INFANT ACCEPTANCE of PURÉED VEGETABLES FROM DAY 2 to 3 of FEEDING

	Score Change								
	-4	-3	-2	-1	=	+1	+2	+3	+4
Frequency	1	5	8	30	217	25	11	6	1

(Harasym, 1977).

APPENDIX I (i)

LETTERS GRANTING PERMISSION TO CONTACT ATTENDANTS OF ST. BONIFACE HOSPITAL PRENATAL CLINIC

Hôpital Général - St. Boniface - General Hospital
409 Tache Avenue,
WINNIPEG, MANITOBA R2H 2A6
(204) 233-8563

September 23rd, 1977

Miss Janet Fabro
Department of Foods and Nutrition
Faculty of Home Economics
The University of Manitoba
Winnipeg, Manitoba
R3T 2N2

Dear Miss Fabro:

I have reviewed your program and agree in principle. However, I am still not certain from your submission exactly how you plan to obtain access to these infants.

I would suggest that once you obtain the names of babies newly delivered, the simplest method would then be to contact the attending physician and obtain his consent.

Please let me know if this is suitable or if more detailed planning is necessary on our part.

Yours sincerely,

Leo J. Peddle, M.D.

LJP:de

THE UNIVERSITY OF MANITOBA
FACULTY OF HOME ECONOMICS
WINNIPEG, CANADA R3T 2N2
TELEPHONE 204 474-9901

DEPARTMENT OF FOODS AND NUTRITION

APPENDIX I (ii)

October 3, 1977.

Dr. Leo Peddle, Department Head,
Obstetrics and Gyaenocology,
St. Boniface General Hospital,
409 Tache Avenue,
Winnipeg, Manitoba.
R2H 2A6

Dear Dr. Peddle,

Thank you for your letter of September 23, 1977. In response to your question, I had planned to obtain the names of the newly delivered babies and their parents from Ms. Caroline Sarzynick, the woman who conducts the prenatal classes at the St. Boniface Hospital. I had then planned to contact the parents by means of a letter to determine whether they would be interested in participating in the study. If they were, I would then interview them to inform them on the purpose of the research, exactly what the study involved and what they would be expected to do.

I had not intended to obtain the consent of the attending physician for each infant. However, if you feel this is necessary, I certainly will. A similar study to mine was conducted last year in the Department by Lynn Harasym, the infants were obtained through your hospital. In this study, the consent of the attending physician was only obtained if the mother requested it. This was the procedure I had intended to follow as well. Please let me know your decision on this matter. Thank you very much.

Yours truly,

Janet Fabro

JF/ja

Janet Fabro.

APPENDIX I (iii)

Hôpital Général - St. Boniface - General Hospital
409 Tache Avenue,
WINNIPEG, MANITOBA R2H 2A6
(204) 233-8563

October 6th, 1977

Miss Janet Fabro
Dept. of Foods and Nutrition
Faculty of Home Economics
University of Manitoba

Dear Miss Fabro:

Thank you for your letter of October 3rd, 1977. I would agree that your planned approach is a reasonable one but would suggest that when approaching the mothers you point out to them that if they desire you will approach their attending pediatrician.

I would see no further problems in this regard. Good luck in your project.

Sincerely yours,

Leo J. Peddle, M.D.

LJP:de

THE UNIVERSITY OF MANITOBA
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DEPARTMENT OF FOODS AND NUTRITION

APPENDIX J

LETTER TO CONTACT SUBJECTS

March 8, 1978.

Dear Parent;

Have you ever wondered why your infant likes some foods more than others? Well, we at the University of Manitoba are trying to find out and we need your help! We wish to investigate the sensitivity of 3 to 8 month old infants to food texture and the basic tastes of sweet, sour and bitter.

Little is known on infant taste sensitivity and even less is known of their perception of food texture and its influence on food acceptance. This study was therefore designed to investigate these two areas.

The St. Boniface General Hospital has given us permission to obtain your name through them. Since you have an infant in this age group, we are writing to enquire whether you and your child would be interested in participating in the study which would run for a total of 18 days in your home.

The food samples for the study consist of apple, pear and potato purées. The samples are in the frozen form and are therefore easy to store and handle. You would be required to feed your child approximately one tablespoon of one sample every day before one of his/her regular meals, simply to get his/her reaction to it. A scale will be provided for you to check off the point which best reflects your child's acceptance of the sample.

....2

THE UNIVERSITY OF MANITOBA
FACULTY OF HOME ECONOMICS
WINNIPEG, CANADA R3T 2N2
TELEPHONE 204 474-9901

DEPARTMENT OF FOODS AND NUTRITION

Should you desire, we would be happy to approach your attending physician with the details of the study to obtain his approval. We will be contacting you by telephone within a week to find out if you are interested and to give you further details. Thank you very much.

Yours truly,

Mina R. McDaniel, Ph. D
Associate Professor.

Janet Fabro,
Graduate Student.

JF/ja

APPENDIX K

Instructions for Handling and Feeding Samples

Please keep all samples frozen until ready for use. The night before a sample is to be used, remove it from the freezer and place it in the refrigerator to thaw overnight.

Remove the sample from the refrigerator 2 hours before it is to be served so that the sample is at room temperature at the time of feeding.

If the sample is to be refed the next day, place it back in the refrigerator overnight; if not, discard.

If the sample is to be refed, again, remove it from the refrigerator 2 hours before feeding so that it is at room temperature at the time of feeding.

Samples are coded as to: on which days of the study they are to be fed. Please serve the appropriate sample once each day BEFORE one of the baby's regular meals, preferably lunch and stir all samples before feeding. Offer enough sample to get the baby's reaction to it and complete the observation sheet. Please serve each sample at approximately the same time of day and in the same manner throughout the study.

PLEASE DO NOT taste the samples yourself as your attitude may influence your baby's acceptance or rejection of the sample.

APPENDIX L

OBSERVATION SHEET

DAY OF STUDY__________ NAME of INFANT______________

DATE__________________ TIME of FEEDING___________

REACTION - PLEASE CHECK ONE

_______OBVIOUSLY LIKES: smiled & cooed throughout feeding; waving of arms & legs; opened mouth willingly & eagerly for next spoonful; impatient for next spoonful; pulled spoon towards mouth; ate willingly and enthusiastically.

_______SEEMS TO LIKE: ate without fussing; ate willingly but not as enthusiastically.

_______INDIFFERENT: ate but with no apparent emotion; did not cry and fuss but showed no signs of enthusiasm.

_______SEEMS TO DISLIKE: fussed; reluctant to take next spoonful; reluctant to swallow; made faces; frowned and grimaced.

_______OBVIOUSLY DISLIKES: spit it out; refused to swallow; refused to open mouth after first taste; cried and fussed; pushed spoon away; backed away from spoon.

Is your baby feeling well today? Yes_____ No_____

If no, please explain:______________________________________

Comments:____

____

APPENDIX M

QUESTIONNAIRE ADMINISTERED TO MOTHERS OF SUBJECTS

NAME OF PARENT(S):______________________________

ADDRESS:______________________________

TELEPHONE NUMBER:______________________________

NAME OF INFANT:______________SEX_______M_______F

DATE OF BIRTH:______________

WEIGHT AT BIRTH:______________

PRESENT AGE:______________

PRESENT WEIGHT:______________

1. Initial Type of Milk Feeding:

   A) Breast ______________

   B) Bottle ______________

      a) Cows Milk
         i) Homo (whole) ______________
         ii) 2% ______________
         iii) Skim ______________

      b) Formula
         i) Commercial ______________
            Name of Product: ______________
         ii) Home Prepared ______________
            Composition: ______________
            ____

2. Present Type of Milk Feeding.

   A) Breast ______________

   B) Bottle ______________

Question 2 cont'd

a) Cows Milk
   i) Homo (whole) ______
   ii) 2% ______
   iii) Skim ______

b) Formula
   i) Commercial ______
      Name of Product: ______
   ii) Home Prepared ______
      Composition: ______

______

c) Both ______
   If c, complete b) of #2.
   If b or c, at what age did you introduce bottle? ______

3. At what age did you first introduce semi-solids to your child? ______
   On who's recommendation? ______

4. What type of semi-solids did you first introduce? (ie. fruit, cereal etc) ______

   Specific kind of product first introduced? (ie. applesauce, oatmeal, etc.) ______

5. Using the scale provided, please indicate how your child reacted to this product when it was first introduced. (1 = least) (please circle)

   1 2 3 4 5

6. Using the scale, please indicate how your child feels about the product now.

   1 2 3 4 5

7. If the product were not accepted at first but is now, or vice versa, how long did it take for this acceptance change to occur?

______

APPENDIX M cont'd

8. Do you prepare your own baby food or use the commercial products? ______________________

9. Check the categories of products which you have introduced to your child up to now. Please state the order in which they were introduced and the age at which they were first introduced.

Product Category	Order	Age of First Intro.
Juices	______	______________
Cereals	______	______________
Fruits	______	______________
Vegetables	______	______________
Meats	______	______________
Meat Dinners	______	______________
Meat & Veg. Combination	______	______________
Desserts	______	______________

10. Using the scale, please indicate how your child GENERALLY reacts to the various product categories: (1 equals least)

Product Category	Reaction (General)				
Juices	1	2	3	4	5
Cereals	1	2	3	4	5
Fruits	1	2	3	4	5
Vegetables	1	2	3	4	5
Meats	1	2	3	4	5

What does your child do that indicates this reaction to you?

Juices ____

____

Cereals ____

____

Fruits ____

____

Vegetables ____

____

Meats ____

____

APPENDIX M cont'd

11. In each product category, please state the TYPE of product that was introduced FIRST. Please indicate your child's REACTION to it when it was FIRST INTRODUCED as well as the reaction to it NOW using the scale. If your child's acceptance of a product type has changed from then until now, please state how long this change took to occur.

Product Category	Type First Introduced	Rx when First Introduced	Rx Now	If acceptance changed how long?
Juices		1 2 3 4 5	1 2 3 4 5	
Cereals		1 2 3 4 5	1 2 3 4 5	
Fruits		1 2 3 4 5	1 2 3 4 5	
Vegetables		1 2 3 4 5	1 2 3 4 5	
Meats		1 2 3 4 5	1 2 3 4 5	

12. In each product category, please state the TYPES of products that have SINCE been fed. Please indicate your child's REACTION to them when they were FIRST INTRODUCED, as well as the reaction to them NOW using the scale. If your child's acceptance of the product type has changed from then until now, please state how long this change took to occur.

Product Category	Types Subsequently Introduced	Rx when First Introduced	Rx Now	If acceptance changed how long?
Juices		1 2 3 4 5	1 2 3 4 5	
Cereals		1 2 3 4 5	1 2 3 4 5	

APPENDIX M cont'd

Product Category	Types Subsequently Introduced	Rx when First Introduced	Rx Now	If acceptance changed how long?
Fruits		1 2 3 4 5	1 2 3 4 5	
Vegetables		1 2 3 4 5	1 2 3 4 5	
Meats		1 2 3 4 5	1 2 3 4 5	

13. Is your baby teething now? ______Yes ______No

If yes, at what age did he/she begin teething? ________________

How many teeth does he/she have now? 0______
1______
2______
3______
4______
over 4(specify number)________

APPENDIX N

SCALE USED BY MOTHERS TO INDICATE FOOD PREFERENCES OF SUBJECTS

______OBVIOUSLY LIKES: smiled & cooed throughout feeding; waving of arms & legs; opened mouth willingly & eagerly for next spoonful; impatient for next spoonful; pulled spoon towards mouth; ate willingly and enthusiastically.

______SEEMS TO LIKE: ate without fussing; ate willingly but not as enthusiastically.

______INDIFFERENT: ate but with no apparent emotion; did not cry and fuss but showed no signs of enthusiasm.

______SEEMS TO DISLIKE: fussed; reluctant to take next spoonful; reluctant to swallow; made faces: frowned and grimaced.

______OBVIOUSLY DISLIKES: spit it out; refused to swallow; refused to open mouth after first taste; cried and fussed; pushed spoon away; backed away from spoon.

APPENDIX O

Consent Form

I, ______________________________, do hereby freely consent to myself and my child __________________________ participating in the study conducted by the Department of Foods and Nutrition at the University of Manitoba entitled "The Sensitivity of Infants to Food Texture and the Basic Tastes of Sweet, Sour and Bitter". The conditions of the study have been fully explained to me by the experimenters and I understand them completely. I also understand that my child and I are free to withdraw from the study at any time without penalty and that all information obtained will remain strictly confidential.

Signature:________________________

Date:_____________________________

APPENDIX P

FREQUENCY DISTRIBUTION OF SCORE CHANGES IN INFANT ACCEPTANCE OF MODEL TASTE AND TEXTURE SYSTEMS FROM DAY 1 TO 2 OF FEEDING

	Score Change								
	-4	-3	-2	-1	=	+1	+2	+3	+4
Frequency	1	0	13	51	305	51	13	1	1

APPENDIX Q

FORMULAS USED IN CALCULATION OF MISSING OBSERVATIONS

$$X3, 17 = \frac{a\,T + b\,B - S}{(a - 1)(b - 2)}$$

$$X5, 17 = 1/2 \left[\frac{a\,T + b\,B - S}{(a - 1)(b - 2)} \right] + 1/2 \left[\frac{a\,T + b\,B - S}{(a - 2)(b - 1)} \right]$$

$$X5, 27 = \frac{a\,T + b\,B - S}{(a - 2)(b - 1)}$$

Where

a = number of treatments

b = number of blocks

T = sum of the observations in the same treatment as the missing observation.

B = sum of the observations in the same block as the missing observation.

S = overall sum of the observations.

APPENDIX R

FORMULA USED TO DETERMINE THE STANDARD ERROR OF THE RANK TOTALS USED IN DUNCAN'S MULTIPLE RANGE TEST ADAPTED FOR USE WITH NONPARAMETRIC STATISTICS

$$\text{Standard Error} = \left[\frac{n(k)\ (k + 1)}{12}\right]^{1/2}$$

Where

k = number of treatments

n = number of blocks.

APPENDIX S

Analyses of Variance Tables for Sensory Characteristics Assessed in Model Taste and Texture Systems

i) Sweetness

Source	df	SS	MS	F - Value	Probability
Tmts.	8	23.51	2.94	34.45	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.64	0.32	3.75	0.05
Interactions					
T x J	40	7.58	0.19	2.22	0.01
J x R	10	0.38	0.04	0.45	n.s.
Error	96	8.19	0.09		
TOTAL	161	40.30			

ii) Sourness

Source	df	SS	MS	F - Value	Probability
Tmts.	7	18.01	2.57	36.69	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.06	0.03	0.43	n.s.
Interactions					
T x J	35	6.11	0.17	2.49	0.001
J x R	10	1.75	0.18	2.50	0.05
Error	84	5.89	0.07		
TOTAL	143	31.82			

iii) Bitterness

Source	df	SS	MS	F - Value	Probability
Tmts	2	10.33	5.17	50.60	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.54	0.27	2.64	n.s.
Interactions					
T x J	10	1.43	0.14	1.40	n.s.
J x R	10	0.94	0.09	0.92	n.s.
Error	24	2.45	0.10		
TOTAL	53	15.69			

iv) Viscosity

Source	df	SS	MS	F - Value	Probability
Tmts.	9	4.43	0.49	21.44	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.14	0.07	3.05	n.s.
Interactions					
T x J	45	3.08	0.07	2.98	0.001
J x R	10	1.04	0.10	4.53	0.001
Error	108	2.48	0.02		
TOTAL	179	11.17			

v) Particle Size

Source	df	SS	MS	F - Value	Probability
Tmts.	3	7.77	2.59	105.95	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.10	0.05	2.05	n.s.
Interactions					
T x J	15	0.91	0.06	2.48	0.05
J x R	10	0.54	0.05	2.21	0.05
Error	36	0.88	0.02		
TOTAL	71	10.20			

vi) Amount of Particles

Source	df	SS	MS	F - Value	Probability
Tmts.	3	3.43	1.14	25.57	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.01	0.01	0.11	n.s.
Interactions					
T x J	15	2.17	0.14	3.23	0.01
J x R	10	0.92	0.09	2.06	n.s.
Error	36	1.61	0.04		
TOTAL	71	8.14			

vii) Pulpyness

Source	df	SS	MS	F - Value	Probability
Tmts.	4	12.56	3.14	37.96	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps	2	0.35	0.18	2.12	n.s.
Interactions					
T x J	20	3.00	0.15	1.81	0.05
J x R	10	0.79	0.08	0.96	n.s.
Error	48	3.97	0.08		
TOTAL	89	20.67			

viii) Gumminess

Source	df	SS	MS	F - Value	Probability
Tmts	9	12.50	1.39	25.34	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.40	0.20	3.65	0.05
Interactions					
T x J	45	6.89	0.15	2.79	0.001
J x R	10	2.11	0.21	3.85	0.001
Error	108	5.92	0.05		
TOTAL	179	27.82			

ix) Dryness

Source	df	SS	MS	F - Value	Probability
Tmts.	8	9.18	1.15	16.37	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.00	0.00	0.00	n.s.
Interactions					
T x J	40	6.87	0.17	2.45	0.001
J x R	10	0.84	0.08	1.20	n.s.
Error	96	6.73	0.07		
TOTAL	161	23.62			

x) Mouthcoating

Source	df	SS	MS	F - Value	Probability
Tmts.	9	5.59	0.62	10.19	< 0.001
Judges	5	0.00	0.00	0.00	n.s.
Reps.	2	0.03	0.02	0.25	n.s.
Interactions					
T x J	45	8.21	0.18	2.99	0.001
J x R	10	1.53	0.15	2.51	0.01
Error	108	6.58	0.06		
TOTAL	179	21.94			