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GENETIC STUDIES OF TASTE PERCEPTIONS OF ANTIDESMA AND PHENYLTHIOCARBAMIDE

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James V. Higgins
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GENETIC STUDIES OF TASTE PERCEPTIONS OF ANTIDESMA AND PHENYLTHIOCARBAMIDE

By

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ABSTRACT

GENETIC STUDIES OF TASTE PERCEPTIONS OF
ANTIDESMA AND PHENYLTHIOCARBAMIDE

By

Frankie Johnson Brown

To investigate the reported association between bitter taste responses to phenylthiocarbamide (PTC) and aqueous extracts of the tropical fruit, Antidesma bunius by Henkin and Gillis, (1977), taste perceptions of 968 unrelated individuals and 470 related subjects (115 families and 12 twin pairs) were assessed for three PTC concentrations (20.31, 40.63 and 81.25 mg/l), two preparations of Antidesma (aqueous extract and liquified macerated materials) and six control solutions (lemon juice, distilled water, 1M NaCl, 0.001M quinine sulfate, 0.5M sucrose and grape juice).

Frequencies of specific taste responses for each solution recorded by all subjects were analyzed by age, sex, race/ethnic group, smoking status and elapsed time since last food eaten and comparisons of PTC and Antidesma perceptions were made. Taste perceptions of PTC and Antidesma obtained from families and twins were additionally analyzed to determine if these responses were consistent with a simple dominant-recessive genetic hypothesis.

Perceptual errors made by subjects in the identification of controls for sweet, tasteless, salty, sour and bitter taste qualities

were less than those reported by previous studies. There were no significant associations of these errors with age, sex, race, smoking status nor elapsed time since food ingestion. Misidentification of controls did not appear to produce significant differences in taste responses to PTC nor Antidesma.

Based on responses to the PTC concentration of 81.25 mg/l, taster and nontaster frequencies were 75.8 percent and 24.2 percent. Corresponding bitter and nonbitter responses were 70.1 percent and 29.9 percent. These frequencies and those obtained for responses to the concentrations of 20.31 and 40.63 mg/l did not appear significantly affected when age groupings were compared. PTC perceptions however, did appear to be affected by sex, race, smoking status and elapsed time since last food eaten.

Diversity of taste perceptions of Antidesma were observed both for the Aqueous extract (Antidesma I) and for liquified macerated materials (Antidesma II). Major perceptions of Antidesma I were sweet (50.9%) and sour (36.0%) and for Antidesma II, sour (45.9%) and bitter (28.2%). The finding of significant differences between the overall responses and for the dichotomous classifications of the major perceptions of these solutions suggested inherent compositional variations. The Antidesma perceptions did not appear to be significantly affected by smoking nor elapsed time since food ingestion. However, effects of age, sex and race were suggested.

Specific taste perceptions of Antidesma I were not significantly associated with any taste response for each of the PTC concentrations nor with PTC tasting status. Conversely, overall perceptions, as well

as bitter-nonbitter perceptions of Antidesma II, showed significant correlations with PTC responses, primarily due to the less than expected frequency of subjects who judged both Antidesma II and PTC as bitter. Contrary to the Henkin and Gillis report however, no mutual exclusivity of bitter perceptions for either Antidesma II or I and PTC were observed.

Results from comparisons of observed and expected PTC taster-nontaster progeny frequencies from various mating types were in excellent agreement with the well established dominant-recessive hypothesis. Support for this genetic hypothesis for Antidesma taste perceptions in families was found only in the case of bitter-nonbitter responses for Antidesma I.

Comparisons of twin concordance rates for Antidesma perceptions revealed no significant differences between concordance of MZ and DZ twins. Similar results were obtained when MZ-DZ twin concordance rates for PTC responses were compared. However, definitive conclusions were unwarranted due to the small sample size of twins studied.

To C. B. and Chuckie and

my parents, William P. and Bernice M. Johnson

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INTRODUCTION

Genetic differences in taste responsiveness were first demonstrated for phenylthiocarbamide (PTC or phenylthiourea) and related compounds. Such taste perception differences are assumed to be dependent upon the presence of the N-C=S radical of these compounds which is typically perceived as bitter or tasteless although other taste qualities have been reported. Since the initial descriptions, numerous population studies have confirmed the divergent taste perceptions for PTC and have resulted in the classification of individuals as tasters or nontasters. The frequency of tasters has been found to be approximately 30 percent in American Caucasian populations but varies from 0-49 percent in other racial groups (Corcos and Scarborough, 1978). Additionally, specific threshold concentration effects have been observed which appear to increase with age and are generally reported decreased in females. Differential frequencies also appear to be associated with certain types of disease entities especially those which relate to thyroid functioning. Furthermore correlations of PTC taste sensitivity have been reported for a variety of other substances.

Taste perceptions of PTC are generally considered to be controlled by a single pair of alleles. The ability to taste PTC is thought to be inherited as a Mendelian dominant while the inability to taste this substance is due to homozygosity for the recessive allele. This

hypothesis has been largely confirmed although occasional incomplete penetrance of the "taster" allele has been reported and a multiple allelic system has been postulated to account for extremely sensitive tasters in certain populations (Das, 1956; Lugg, 1970).

Recently, Henkin and Gillis (1977) confirmed divergent taste responses to extracts from berries of the Antidesma bunius tree. Their investigation was initiated in response to a prior incident in which two of eight persons served a pie made from Antidesma berries complained that the pie was extremely bitter and inedible while the other six persons found the pie pleasant tasting and sweet. These observations were considered unusual since it was known that Antidesma fruit has been extensively used as food by natives of South East Asia and Florida and for many years has been eaten in pies, jams, jellies and sauces or as raw fruit.

In the study of 170 subjects, Henkin and Gillis not only found differences in taste perceptions to extracts prepared from Antidesma fruit but also concluded that these differences were specifically related to taste perceptions of PTC. In their study, responders to PTC and Antidesma extract were defined as those who described these solutions as bitter while non-responders were defined as those who judged the solutions as either tasteless or of another taste quality. Among the bitter responders to PTC, there were no bitter responders to Antidesma and conversely, among the bitter responders to Antidesma, there were no bitter responders to PTC. Based on these observations, these researchers concluded that some type of interaction may exist between those factors which are responsible for bitter cognition of these two substances since no single individual sampled perceived both

of these as bitter. Furthermore they suggest that the relationship of these factors may occur on a functional or a genetic level.

In view of these findings the present study was proposed to sample larger numbers of subjects to establish frequencies of different taste responses of Antidesma, to further investigate the associations between Antidesma and PTC perceptions and to conduct family studies to determine if divergent taste responses to Antidesma conform to a simple genetic hypothesis.

LITERATURE REVIEW

Among the numerous attributes used to describe diversity in human populations are those involving variations in drug sensitivity. One of the most widely investigated of these is taste perceptions of phenylthiocarbamide (PTC or phenylthiourea) which were first described in 1931. A. L. Fox (1931) who had synthesized this substance received complaints from colleagues saying that the laboratory air contained an intensely bitter dust. Fox and some of his other colleagues, however, did not perceive this bitter sensation and when he placed PTC crystals on the tongues of various individuals he found that some experienced the intensely bitter taste while others found the crystals tasteless. Since this initial description, investigations conducted in numerous populations have confirmed the taster-nontaster dichotomy.

PTC is a synthetic organic compound, belonging to a group of chemically related substances commonly regarded as goitrogens because of their anti-thyroid activity. Over 100 of these compounds both naturally occurring and synthetic are now known and they are related in chemical structure by the presence of a N-C=S group. This common chemical grouping has been shown to be responsible for the bitter perceptions of sensitive individuals (Fox, 1932; Hopkins, 1942; Harris and Kalmus, 1950; Barnicot et al., 1951).

Not all persons find the taste of PTC bitter or neutral. Blakeslee and Fox (1932) and Blakeslee (1935) as well as others have reported that some people find PTC sweet and others find it salty, sour, camphory or sulfury. Skude (1959, 1960a) reported that about 7-9 percent of his population tested found PTC sweet tasting and he considered this to be an inherited characteristic. Later with repeated testing of these subjects he found considerable variation in responses and thus suggested that further study was required before definitive conclusions could be drawn (Skude, 1960b). The finding of these "deviant" PTC taste responses has however, led to inconsistencies in classifications by some workers. In some studies individuals are classified as tasters regardless of which type of taste quality is perceived while other studies record tasters as only those who judge PTC as bitter.

A variety of methods have been used to study the PTC tasting phenomenon. In earlier studies, PTC crystals were placed directly on the tongue. Later it became popular to impregnate filter papers with certain concentrations of PTC, let the papers dry then have individuals chew on the paper beginning with the lowest concentrations and proceeding to higher concentrations. By this method, thresholds of sensitive individuals could be determined and typically resulted in a bimodal distribution in which the antimode was taken as the dividing line between tasters and nontasters. Another technique used to determine thresholds was introduced by Blakeslee (1932) and refined by Hartman (1939) involved taste testing by use of varying concentrations of PTC in solutions. This latter method was thought to result in a lower percentage of misclassifications of the three techniques. A revised

version of the solution method as employed by Harris and Kalmus (1949), has been used for most population studies with minor variations by several researchers. In the majority of these studies the solution containing 81.25 mg/l has been used to separate tasters from nontasters.

When these methods were used to determine PTC threshold perteptions, population differences with respect to sex have been noted. While the absolute proportions of tasters and nontasters appear to be of equal frequency in males and females, several studies have concluded that on the average, female tasters can detect PTC in higher dilutions (Hartman, 1939; Falconer, 1946; Mohr, 1951; Montenegro, 1964). In some studies, the sex differences have been highly significant while others report only slight differences in sensitivity between the sexes (Than-Than-Siht et al., 1974).

An additional variation in threshold sensitivity has been observed with age. Harris and Kalmus (1949) in a study of 441 British males, found that the modes of the taster and nontaster groups, as well as the antimode dividing the two groups were shifted in the direction of the more concentrated solutions with increasing age. They concluded that a deterioration of taste sensitivity of about one dilution step occurs for each additional twenty years of age. Although less drastic changes have been noted by other researchers (Mohr, 1951), it is generally agreed that PTC sensitivity decreases with age.

Shortly after the initial descriptions of divergent taste responses to PTC, independent studies conducted by Blakeslee (1932) of 103 families and Snyder (1932) of 800 families concluded that this taste sensitivity was an inherited phenomenon which was determined by a single pair of alleles. Furthermore, it was suggested that the ability

to taste PTC was determined by a Mendelian dominant while nontasters were homozygous for the recessive allele. In the development of these hypotheses, Snyder (1932) formulated his now classic ratios for testing data from family studies for a simple dominant-recessive mode of inheritance. His initial assumption that nontasting is recessive was based on the observation that matings of nontaster parents produced almost exclusively nontaster offspring while matings of tasters produced both taster and nontaster progeny. Thus tasters would be homozygous or heterozygous for the dominant taster allele. Then assuming Hardy-Weinberg conditions in which the frequency of the homozygous dominant (taster) = p^2, heterozygotes (tasters) = 2pq and homozygous recessives (nontasters) = q^2, Snyder concluded that it was possible to predict the percentages of recessive offspring expected from various matings of parents displaying the dominant or recessive trait using the following formulae (for derivations, see Appendix A):

Percent Recessives From Dominant x Recessive Matings:

$$S_1 = \frac{q}{1 + q}$$

and

Percent Recessives From Dominant x Dominant Matings:

$$S_2 = \frac{q^2}{(1 + q)}2$$

(Snyder, 1932:Modified).

Analysis of PTC pedigree data by use of these ratios produced close agreement of expected and observed frequencies, thus it was assumed that a single pair of alleles was responsible for the inheritance of taste reactions to PTC.

Despite the apparent "goodness of fit" for Snyder's genetic model, others have proposed modifications of this simple dominant-recessive inheritance pattern for PTC perceptions. In an analysis of 845 sibling pairs, Das (1956) concluded that his results could be best explained by modifying the monogenic theory to assume 90 percent penetrance of the dominant allele.

Additional support for reduced penetrance as well as variable expressivity of the taster allele has been provided by the finding that some people are able to detect the bitter taste at very high dilutions while others detect it only with crystals. (Some individuals have also been discovered who are unable to taste extremely high solution concentrations nor the PTC crystals.) Furthermore, studies by Lugg (1966, 1968, 1970) have suggested that a multiple allelic hypothesis is necessary to account for the multimodal threshold distributions obtained in his study of population groups containing individuals with unusually high PTC taste acuity. Similar conclusions have been reached by Rychkov and Borodina (1973), from extended investigations of PTC hypersensitivity from which they proposed triallelic autosomal control of PTC sensitivity. Other researchers have suggested a polygenic inheritance mode. These hypotheses however have not been supported by others. Indeed, extensive studies by Rao and Morton (1977) of PTC taste sensitivity in a large sample from Brazil (2,090 parents and 2,245 offspring) and subsequent application of a mixed model of complex segregation analysis have found no evidence for incomplete dominance, polygenic variation, nor did they suggest any effect of family environment on PTC sensitivity. They concluded that skepticism about simple recessivity is unwarranted.

Numerous population studies have revealed considerable differences in the proportion of tasters and nontasters in different parts of the world. These studies have been important for anthropological reasons to suggest possible ethnological factors involved in PTC sensitivity. Among the Caucasian populations of Western Europe and North American origin, the frequency of nontasters is approximately 25-35 percent (Allison and Blumberg, 1959), among American Negroes, 8-20 percent (Johnston et al., 1966; Lee, B. F., 1934), among African Blacks, 3-12.5 percent (Barnicot, 1950; Scott-Emuakpor et al., 1975), among Chinese, 6-10.6 percent (Cohen and Ogden, 1949; Barnicot, 1950), among American Indians, 6 percent (Cohen and Ogden, 1949). In general, it appears that Negroid, Mongoloid and American Indian populations are characterized by a lower percentage of nontasters (less than 20 percent) while Caucasian populations typically contain 25-35 percent nontasters. The highest nontaster frequencies (greater than 50 percent) have been reported for certain Australian aborigines and some groups in India (Basu and Ghost, 1968). The nontaster frequencies for other groups may vary from 0-49 percent depending on geographical origin and racial composition (Corcos and Scarborough, 1978; Garr, 1934).

Appearance of the PTC taste divergence dates back to prehuman times. Fischer et al. (1939) in a study of chimpanzees in Great Britain zoos found a frequency of 26 percent nontasters. Corresponding values for nontasters in their human population studies were 25-30 percent. From these observations, it was concluded that such consistency between human and anthropoid groups is attributable to "a stably balanced and enduring dimorphism that has kept the ratio the same over millions of generations since the separation of anthropoid and humanoid stock."

The maintenance of the PTC taste polymorphism has been the subject of much speculation. As with other polymorphisms, it is believed that this kind of biochemical diversity can only be maintained by a balance of selective forces acting on the various phenotypes.

Several theories concerning the possible selective advantage of both tasters and nontasters have been postulated. Basic to these hypotheses have been the observations of differential frequencies of taste sensitivities associated with various human conditions. The following represents an enumeration of some of the more widely studied associations. A significant increase in taster phenotypes has been reported to be correlated with dental caries in adults under the age of 40-50 (Tibera-Dumitru, 1965), malignant tumors of the ovaries, uterus and breasts in females (Milunicova et al., 1969), inflammatory diseases (such as rheumatoid arthritis and ankylosing spondylitis, Stepan et al., 1965), greater maturation in visual-motor perception (Greene, 1974), increased skeletal maturity (Johnston et al., 1966), and tuberculosis (Saldanha, 1956). Conversely, the proportion of nontasters is reputedly increased in primary glaucoma diseases (Becker and Morton, 1964) and diabetes mellitus (Terry, 1950; Rao and Sisodia, 1970). It should be noted that the above associations with tasting status have not been universally confirmed by subsequent studies but merely suggest possible mechanisms by which various taster alleles may be maintained in populations (Kalmus and Lewkonia, 1973; Lasker and Fernandez, 1970).

Perhaps the most widely studied relationships linked to the PTC polymorphism have been those involving thyroid functioning, some of which have been alluded to earlier. Investigations of this association have been numerous because of the well known goitrogenic effects of PTC

related compounds. Furthermore, a number of these related antithyroid compounds are present in small amounts in many edible plants of the Brassica genus including cabbage, kales, brussel sprouts, turnips, etc. (Boyd, 1950; Van Etten, 1969). Since PTC itself does not occur in nature, what is seen as the PTC taste polymorphism has been thought to reflect individual ability to detect and perhaps reject a large number of naturally occurring goitrogens. Studies by Greene (1974) on iodized and noniodized populations in which goiter is endemic in areas where a number of PTC like goitrogen containing plants are consumed in moderate quantities, have found significant correlations between PTC taste sensitivity and visual-motor maturation and an increase in taste sensitivity with age in the noniodized individuals but not in those which were iodized. From these findings the author concludes that sensitive tasters of PTC may limit their ingestion of the bitter tasting goitrogens, reduce the stress placed on their thyroid gland and thus increase the likelihood of normal neurological maturation under these particular environmental conditions.

Several other reports have linked the ingestion of plant produced goitrogens with endemic goiter (Clements and Wishart, 1956; Greene et al., 1958; Peltola, 1960; Barzelatto and Covarrubias, 1969). Additional studies have confirmed the linkage of PTC taste sensitivity to goiter, both sporadic (Harris et al., 1949; Kitchin et al., 1959) and endemic (Brand, 1963; Azevedo et al., 1965). Most of these studies have concluded that nontasters show a significantly increased prevalence of nodular as opposed to diffuse goiter (Mendez et al., 1972; Boyce et al., 1976). Furthermore, other investigations have found a significant excess of nontasters among athyreotic cretins as well as a similar

increased nontaster frequency among the parents and siblings of the cretins (Shepard and Gartler, 1960; Shepard, 1960; Fraser, 1961). These researchers suggest that "the nontaster fetus may be more susceptible to embryonic thyroidectomy by naturally occurring goitrogens in the diet of the mother." Such conclusions have led to the hypothesis that tasters are at a selective advantage over nontasters under environmental conditions where iodine intake may be low and naturally occurring goitrogens are consumed in significant quantities.

Under different conditions selection may favor the nontaster phenotype. Evidence for this assumption has been suggested by the significantly lower prevalence of hyperthyroidism (toxic goiter) among nontasters (Kitchin et al., 1959; Persson et al., 1972). In fact, Farid et al. (1977) have suggested that tasters who also possess the HLA B-8 antigen have a 5-8 fold increased risk of developing Graves disease (a form of hyperthyroidism). Additionally, Milunicova et al. (1969) have demonstrated a significantly lower incidence of carcinoma of the thyroid among women who are nontasters.

From the foregoing, it has been assumed by several researchers that the tasting polymorphism has probably been maintained due to selection against the two homozygote genotypes under different conditions and perhaps even at different points in the life cycle, thus producing relative heterozygote advantage (Greene, 1974). What is unclear however, is the mechanism of action of the taster alleles. Whether they simply represent a pleiotropic expression of genes coding for thyroid function or merely those responsible for some variation in the rejection mechanism or disposal of antithyroid substances remains unknown (Fraser, 1961; Kalmus, 1972). At present there exists no satisfactory

evidence to prove a causal relationship between PTC tasting status and the occurrence of both thyroid and nonthyroid related conditions in human populations.

Of the more interesting nonpathologic associations of taster status of PTC, have been those involving relationships with taste perceptions of other substances. As indicated earlier, most of these correlations have been established for the more than 100 PTC related compounds which contain the N-C=S group. Such substances show threshold taste distributions in populations similar to those of PTC. A small number of investigations however, have been undertaken which suggest associations of PTC perceptions and other non-PTC like compounds. It is of interest that most of these compounds have been those which elicit bitter perceptions to most individuals and have been studied presumably to assist in elucidating the physiological nature as well as number and types of receptors responsible for bitter cognition in humans. Fischer and Griffin (1964) have reported that the degree of sensitivity for quinine, influences the expression of taste sensitivity for PTC-type compounds such as 6-N-propylthiouracil (PROP). Their data showed that the average PROP taste threshold for each of the tasting and nontasting modes is significantly higher for very insensitive tasters of quinine than for sensitive tasters. These workers suggest that the influence of quinine taste sensitivity on the expression of PROP responsiveness may be regarded as an example of partial epistatis in humans. A more recent study by Bartoshuk (1979) suggested that the intensity of the bitter taste of saccharin is also related to the taste sensitivity to PROP. Based on an analysis of scaled intensities of the sweet, salty, sour and bitter taste qualities of sodium saccharin by tasters and

nontasters of PROP, it was concluded that saccharin tastes significantly less bitter to nontasters at the concentrations used in popular diet beverages. Hall et al. (1975) have examined the relationship between PTC taste perception and the taste of caffeine. Their assessment of taste thresholds for PTC and caffeine produced a bimodal distribution for both of these compounds. The bimodality of caffeine thresholds however, was restricted to the lower concentrations but was highly correlated to PTC thresholds. Thus these workers concluded that sensitivity to the taste of PTC predicts sensitivity to caffeine. Another apparent relationship to PTC perceptions which has formed the basis for the present study were the findings of Henkin and Gillis (1977) which linked specific PTC perceptions to aqueous extracts from berries of the Antidesma bunius tree. Since information about this fruit is not widely disseminated, a brief description of the plant as well as the findings of these workers follows.

Antidesma bunius is a member of a large genus of dioecious shrubs and small trees of the family Euphorbiaceae native to tropical Asia, Africa, Australia and the Pacific, particularly in the islands of the Phillipines, Indonesia and the Malay Peninsula (Burkill, 1935; Benthall, 1946). In these areas the plant is referred to by a variety of common names depending on the area in which it grows (e.g., Bignay in the Phillipines, Booni in Malay, Boorneh in West Java, etc., Fairchild, 1939). Introduction of the fruit in this country appears to have occurred around 1913 according to a U.S. Department of Agriculture Report and since that time, has been grown exclusively in South Florida, specifically in the Fairchild Tropical Gardens near Coconut Grove, Florida (Fairchild, 1939; Sturrock and Menninger, 1946). The fruit

grows in large clusters like grapes (Fig. 1, 2 and 3) although each fruit is about the size and color of a blueberry when ripe and is typically described as ovoid, fleshy and sub-acid, each containing a single seed. The fruiting season varies in different parts of the world but in this country, fruits are commonly found from late summer to early winter.

The scientific name Antidesma was given to the tree to denote its use by natives of Ceylon as a cure for snake bite, according to the Dutch botanist, J. Burmann (1737). According to Burkill (1935), the bark is poisonous, containing an alkaloid but is used medicinally and in the making of rope. The leaves have also been used for medicinal purposes as a diaphoretic and when young, are boiled and used in cases of syphilitic affectations (Drury, 1873), and in some cases are reported to be used to relieve nausea caused by overeating (Ochse, 1931). Young leaves are also eaten raw or steamed with rice. Medicinally, the fruit itself is considered to have excellent cooling properties. At maturity, the ripe fruits are very juicy and considered sweet but somewhat acid (Mowry and Toy, 1941). They may be eaten raw as a delicacy or made into jams, wines, sauces for fish and are often used in preserving (Brown, 1954; Burkill, 1935). Analyses of the fruit show that it is a good source of calcium and has a fair amount of iron (Maranon, 1935). In South Florida the fruit has enjoyed some popularity since 1939 and has been used there for the past four decades in pies, jellies, juices or eaten raw in a manner similar to that of raspberries, currants or the blueberries which it resembles (Fairchild, 1943).

In 1972, at a luncheon for eight people, during which a pie made from the Antidesma berries was served, two persons at the table, after their first bite, complained that the pie was extremely bitter,

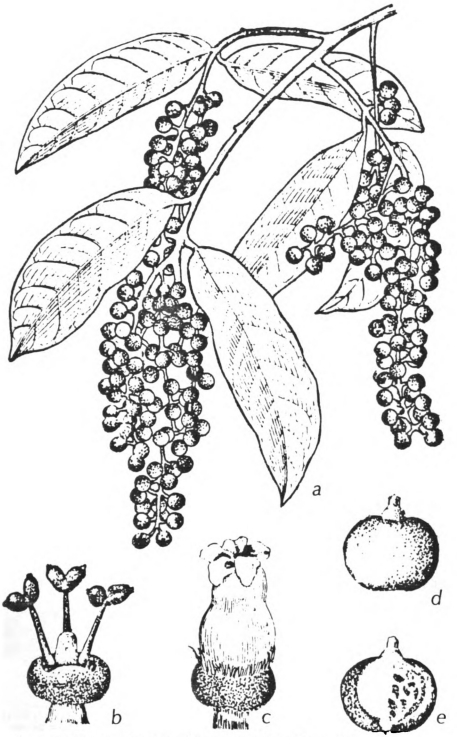
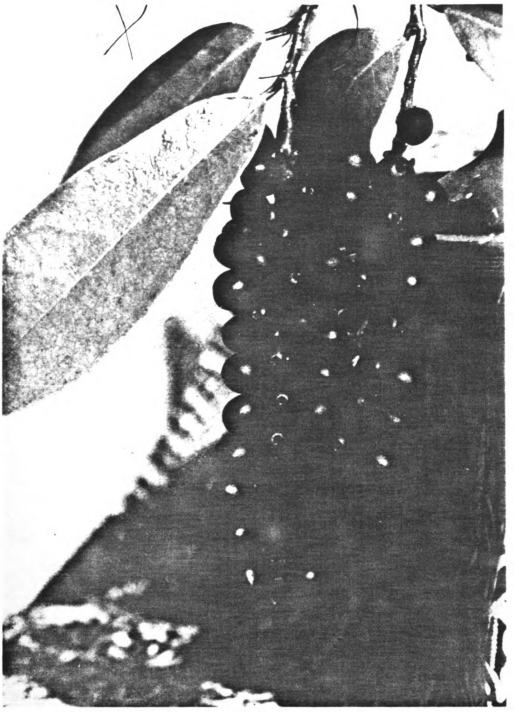


Fig. 1. *Antidesma bunius* (Bignai). a. Fruiting branch. b. male flower. c. female flower. d. fruit. e. section of fruit.

(Brown, 1954)



One of the most delicious and beautiful of the jellies for sale on the Miami market is made from the almost black fruits of this Antidesma bunius. When in fruit the tree is completely covered with these black clusters, making it a spectacular sight.

(Fairchild, 1939)

Fig. 2.--Tree of Antidesma bunius.

Tree of Antidesma bunius, on "The Kampong," that bears several bushels of fruit every August. It began bearing when six years old and might be compared with a giant currant bush for the clusters of fruit hang down in a similar way and make a delicious jelly that is comparable in color and quality to currant jelly. It has several names in Java and the Philippines but its scientific name has become established here. Nathan Sands, who takes care of it, posing.

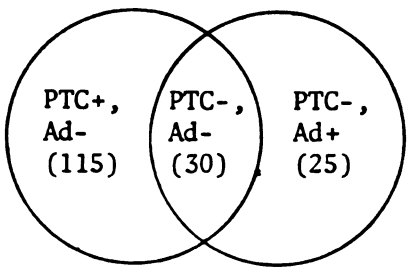
(Fairchild. 1939)

Fig. 3.--Fruits of Antidesma bunius.

so much so that they considered it inedible. However, the other six persons at the table found the pie pleasant tasting, enjoyably edible and sweet. This incident, reminiscent in some manner of the divergent responses to PTC prompted a survey of taste responsiveness to this material by Henkin and Gillis (1977).

In their study of 170 subjects, these workers not only found differences in taste perceptions to Antidesma fruit but also concluded that these differences appeared to be associated with the ability to taste PTC. In their study, responders to PTC and Antidesma extract were defined as those who described these solutions as bitter while nonresponders were defined as those who judged the solutions as either tasteless or of another taste quality (salty, sweet or sour). Subjects were also requested to record the intensity of their taste sensations on a scale of 1-100 based on their previous taste experiences.

Of the 170 subjects studied, there were 115 PTC responders and 55 PTC nonresponders. Antidesma responders and nonresponders were 25 and 142 respectively. Among the 145 nonresponders to Antidesma, 67 judged the extract as slightly sour, 39 as sweet, 29 as salty and 10 could not designate any specific taste quality. A most interesting finding was the fact that among the 25 responders to Antidesma, there were <u>no</u> responders to PTC and among the 115 responders to PTC, there were <u>no</u> responders to Antidesma. Thus according to the data presented, three types of individuals were identified (Fig. 4): (1) PTC responders-Antidesma nonresponders, (2) Antidesma responders-PTC non-responders, and (3) PTC nonresponders-Antidesma nonresponders. As can be seen, none of the individuals tested were responders (had bitter perceptions) to both Antidesma and PTC. These observations suggested



Key to Abbreviations:

PTC+ = PTC Responders
PTC- = PTC Nonresponders
Ad+ = Antidesma Responders
Ad- = Antidesma Nonresponders

Fig. 4.--Antidesma and PTC Taste Responses (based on data from Henkin and Gillis, 1977. For details of data reported, see Appendix B).

some type of interaction between the factors which determine the bitter response to PTC and those which are responsible for the bitter response to Antidesma. Although these researchers inferred that this relationship may exist on a functional or genetic level, definitive conclusions regarding the nature of the interaction and inheritance pattern, if any, could not be formulated due to the relatively small numbers of individuals sampled and the lack of appropriate family studies.

In light of the above findings, the present study was proposed to: (1) sample larger numbers of individuals to establish frequencies for taste responsiveness to Antidesma by age, sex and racial groupings; (2) to confirm or refute the reported associations between Antidesma taste perceptions and taste responses to PTC and (3) conduct family studies to determine if the perceptions of Antidesma can be accounted for by a simple genetic hypothesis.

The significance and utility of studies of this nature may be manyfold. If divergent responses to Antidesma are confirmed, this may stimulate a similar search and description of other naturally occurring substances for which such responses may be discovered and thus perhaps increase our understanding of the influences which these types of

substances exert on food and drink preferences and intake. If the Antidesma responses are found to conform to a specific genetic pattern, this may provide additional evidence that preferences for some food and drink may be determined, at least in part, by genetic factors. Furthermore, confirmation of divergent Antidesma responses as reported earlier may lead to their use as markers descriptive of other human diversity parameters in population studies. Such markers may not only relate to food and drink preferences but also to drug responsiveness. Finally, as suggested earlier, such studies involving investigations of bitter responses may be useful in providing further information regarding the psychophysical and biochemical characteristics of bitterness, particularly with respect to the number and nature of bitter receptors in humans.

MATERIALS AND METHODS

Sampling Procedures

This study was conducted using random individual and family volunteers from which two major population samples were generated.

Population I--Unrelated Subjects

Individuals in this group consisted of volunteers from students and staff of Michigan State University. Staff members were sent memos or contacted directly to request their participation in the study. Student volunteers were primarily solicited from their Natural Science classes. Following a brief explanation of the purposes, risks and requirements of participation, individuals who agreed to volunteer were instructed to come in groups of two or three to a nearby sampling area for testing.

Population II--Family Study Subjects

Initially, one complete East Lansing subdivision consisting of 112 households was selected to approach for family volunteers. Letters were sent to these households in two stages. The first mailings, sent to approximately one-half of the households, introduced and explained the project (copy in Appendix C). Each of these households was subsequently contacted directly at their home for further explanations and to schedule them for testing if they agreed to participate. (Note: Care

was taken to make sure that sampling included only "intact" families, that is, those families in which both mother, father and their natural children were present in the household. Children under the age of seven were excluded to minimize the possibility of misclassification of taste perceptions and misinterpretation of instructions during sampling due to young ages.) The second mailings, sent to the other half of the subdivision households, contained similar information as the first mailing but also included more detailed explanations and a form for each family to complete and return (copy in Appendix C). Consenting families were contacted by phone for scheduling. Additional families were obtained by personal referrals from families who had already participated in the study.

Testing Procedures

Prior to any taste testing, an information and consent form was presented and thoroughly explained to all subjects (copy in Appendix D). Following the signing of the consent form, each individual was requested to complete the demographic portion of the survey questionnaire provided (copy in Appendix D). In cases where more than one subject was being tested concurrently, each person was then positioned so that they were unable to observe the other(s) and explanations of the testing procedure were given. During this time, subjects were cautioned to refrain from making any verbal comments or gestures during the course of the taste sampling which might influence others being tested. Each subject was provided with unsalted crackers and a cup of distilled water to be used prior to the beginning of taste sampling and between each sample tasted to help neutralize taste flavors.

During the course of the taste sampling, subjects were seated and required to tilt their heads back and open the mouth with the tongue extended while keeping their eyes closed. Two to three drops of each solution to be tasted were flowed in turn over the surface of the tongue by means of glass droppers. Subjects were then instructed to taste the solution, record their perceptions by circling the appropriate taste quality (tasteless, salty, bitter, sweet or sour) for each solution and rate the intensity of their perceptions on a scale of 1-5 based on their previous taste experiences. If the solution was thought to be recognized by the subjects, they were requested to describe this in the appropriate place on the questionnaire form.

Taste Solutions Preparation and Processing

The taste sampling panel was designed to assess taste perceptions for eleven different solutions and included two samples of Antidesma, three concentrations of PTC and six samples which served as control solutions.

Solution A--Antidesma I:

An aqueous extract of Antidesma was prepared by gently pressing fresh berries of Antidesma bunius in four thicknesses of cheese cloth. The resultant liquid was filtered through #4 Whatman filter paper. The extract was stored at 0°C in 30 ml aliquots and thawed when needed.

Solution B--Sour Control:

This solution consisted of commercially prepared natural strength reconstituted lemon juice (Realemon--Borden, Inc.) and was used at full strength. Bottles were purchased locally and stored at 4°C until used.

Solution C--Tasteless Control:

Aliquots of distilled water were used for this solution.

Solution D--Salty Control:

A 1 Molar salt solution was prepared by dissolving 58 grams of sodium chloride in one liter of distilled water.

Solution E--Bitter Control:

This solution consisted of 0.001 Molar quinine sulfate (Eli Lilly & Co.) and was prepared by dissolving 714.87 mg quinine sulfate in one liter of distilled water.

Solution F--Sweet Control:

A 0.5 Molar solution of sucrose was prepared by dissolving 171 gm of sucrose per liter of distilled water.

Solution G--Antidesma II:

Antidesma materials (skins, pulp, seeds, etc.) which remained from preparation of solution A (Antidesma I) were macerated by mortar and pestle to produce this solution. Aliquots derived were stored and used as indicated for solution A.

Solutions H, I and J--Phenylthiocarbamide:

A stock solution of PTC (Sigma Chemical) was prepared by dissolving 81.25 mg per liter. This was used at full strength as solution J. Serial dilutions of the stock solution were made to give two additional concentrations of 40.63 mg/liter (Solution I) and 20.31 mg/liter (Solution H). Subjects were always required to taste the most dilute concentration first then progress up to the more concentrated solutions.

Solution K--"Fruit" Control:

This solution consisted of commercially prepared unsweetened grape juice (Welch Foods, Inc.) and was used full strength from locally purchased bottles. As with the lemon juice in solution B, care was taken to open and use only small portions at a time to maintain freshness.

For taste sampling purposes, all solutions were stored and dispensed from 1 oz. dark-colored glass-dropper bottles and were stored at 4°C when not being used. Solutions were renewed every 3-4 days to insure freshness.

RESULTS

Overall Taste Perception Frequencies and General Demographic Data

All sampling for this study was conducted between September 1979 and May 1980 and resulted in the testing of a total of 1,438 individuals. Of this number 968 subjects (Population I) represented unrelated individuals and 470 subjects (Population II) were related. This latter group consisted of 112 two generation families, 3 three-generation families and 12 pairs of twins.

During the course of the study, sampling was conducted at frequent intervals during the day. The time of testing depended on the time of availability of subjects and occurred between 8:08 a.m. and 11:30 p.m. The mean time of testing was 2:20 p.m. and the median was 1:30 p.m. Most of Population I (unrelated-students and staff) were tested during the weekday mornings and afternoons while most of Population II (families) were tested during the weekday evening hours as well as mornings and afternoons on Saturdays and Sundays.

Ages of subjects ranged from seven to seventy-two years, with a mean age of 21.9 years (median = 18.2 years) and included 620 (43.1 percent) males and 818 (56.9 percent) females. Six different racial groups were also represented: 1,213 (84.4 percent) White/Caucasians, 198 (13.8 percent) Black/Afro Americans, 13 (0.9 percent) Chicano/

Mexican Americans, 7 (0.5 percent) Asians, 6 (0.4 percent) Spanish American/Hispanics, and 1 (0.09 percent) American Indian.

Other frequencies obtained included smoking status and elapsed time since last food eaten. The sample contained 258 (17.9 percent) smokers and 1,180 (82.1 percent) nonsmokers. Time of last food eaten by subjects prior to testing ranged from approximately 0.1 hours to 22.6 hours with one subject having not eaten in 50 hours. The mean elapsed time since last food eaten was 4.173 hours with the mode being 1.3 hours and the median 2.098 hours.

The summary of taste responses obtained from the total population sampled is presented in Tables 1-4. Table 1a reports the taste perceptions of individuals for the control solutions, while the intensities recorded for these items are shown in Table 1b. As can be seen, for the four basic taste qualities (salty, bitter, sweet and sour), sweet and salty were most likely to be perceived as anticipated (98.6 percent and 97.5 percent). Expected perceptions of the tasteless controls were also at a high rate (98.1 percent). For the bitter control, 93.4 percent of subjects responded as expected. Of those misclassifying this control, a majority of these subjects judged it as sour (5 percent). Eleven subjects found the bitter control tasteless. The largest misclassification occurred in perceptions of the sour control where 82.1 percent of subjects judged this as sour while 16.5 percent responded bitter. Perception of the "fruit control" shows that a majority of subjects judged this as sweet (73.2 percent) or sour (24.6 percent) while a few individuals found it bitter (2.0 percent) or salty (0.2 percent). No one found this solution tasteless. A comparison of intensities of controls as presented in Table 1b shows that the sweet control

Table 1a.--Taste Perceptions of Controls.

	Sour Control		Tasteless Control		Salty Control		Bitter Control		Sweet Control		"Fruit Control"	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless	0	0.0	1411	98.1	1	0.09	11	0.8	1	0.09	0	0.0
Sour	1181	82.1	8	0.6	8	0.6	72	5.0	9	0.6	354	24.6
Sweet	13	0.9	7	0.5	4	0.3	0	0.0	1418	98.6	1052	73.2
Bitter	237	16.5	9	0.6	23	1.6	1343	93.4	8	0.6	29	2.0
Salty	7	0.5	3	0.2	1402	97.5	12	0.8	2	0.1	3	0.2
Total	1438	100.0	1438	100.0	1438	100.0	1438	100.0	1438	100.0	1438	100.0
Overall Frequency of Misclassification	17.9%		1.9%		2.5%		6.6%		1.4%		--	

Table 1b.--Intensities of Controls.

	Sour Control		Tasteless Control		Salty Control		Bitter Control		Sweet Control		"Fruit Control"	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0	0	0.0	1411	98.1	1	0.09	11	0.8	1	0.09	0	0.0
1	21	1.5	20	1.4	49	3.3	65	4.5	138	9.6	94	6.5
2	66	4.6	7	0.5	156	10.8	100	7.0	263	18.3	229	15.9
3	196	13.6	0	0.0	366	25.5	194	13.5	469	32.6	391	27.2
4	514	35.7	0	0.0	460	32.0	347	24.1	409	28.4	466	32.4
5	641	44.6	0	0.0	407	28.3	721	50.1	158	11.0	258	17.9
Total	1438	100.0	1438	100.0	1438	100.0	1438	100.0	1438	100.0	1438	100.0
	Mean = 4.17 Mode = 5 Median = 4.35		Mean = 0.03 Mode = 0 Median = 0.01		Mean = 3.71 Mode = 4.0 Median = 3.82		Mean = 4.06 Mode = 5 Median = 4.5		Mean = 3.13 Mode = 3 Median = 3.18		Mean = 3.39 Mode = 4 Median = 3.51	

was perceived as less intense than the other controls (mean intensity = 3.13) followed by the "fruit control" (mean intensity = 3.39) and the salty control (mean intensity 3.17). The greatest intensities were recorded for the sour control (mean intensity = 4.17) and for the bitter control (mean intensity = 4.06); median values and modes for intensities of controls are also recorded in Table 1a. (Note: Intensities of 0 represent individuals who judged controls as tasteless.)

Perceptions of the two Antidesma preparations are recorded in Tables 2a and 2b. As can be seen, a majority of subjects judged Antidesma I (juice) as sweet (50.9 percent) or sour (36.0 percent) while 11.7 percent perceived this solution as bitter and a much smaller number found it tasteless (0.8 percent) or salty (0.6 percent). For Antidesma II (macerated material), most subjects perceived this as sour (45.9 percent), bitter (28.2 percent) or sweet (25.4 percent). Eight individuals judged this as salty while no subject found it tasteless. From these values, it will be noted that twice as many respondents reported Antidesma I as sweet as those for Antidesma II while nearly $2\frac{1}{2}$ times as many subjects judged Antidesma II as bitter as did those for Antidesma I. Inspection of intensities reported for both antidesma solutions in Table 2b shows that individuals perceived Antidesma II as more intense (mean intensity = 3.1) than Antidesma I (mean intensity = 2.47).

A comparison of taste responses to the Antidesma solutions and misclassification of control solutions was made to determine relationships between these two variables. For these analyses subjects were divided into three groups based on their perceptions of controls: (1) Individuals who made no errors (misclassifications), (2) Individuals who misclassified one control and (3) those who misperceived two or

Table 2a.--Taste Perceptions of Antidesma.

	Antidesma I		Antidesma II	
	No.	%	No.	%
Tasteless	12	0.8	0	0.0
Sour	517	36.0	660	45.9
Sweet	732	50.9	365	25.4
Bitter	168	11.7	405	28.2
Salty	9	0.6	8	0.5
Total	1438	100.0	1438	100.0
Bitter	168	11.7	405	28.2
Nonbitter	1270	88.3	1033	71.8

Table 2b.--Intensities of Antidesma.

	Antidesma I		Antidesma II	
	No.	%	No.	%
0	12	0.8	0	0.0
1	278	19.3	178	12.4
2	458	31.8	295	20.5
3	443	30.8	405	28.2
4	202	14.0	328	22.8
5	45	3.1	232	16.1
Total	1438	100.0	1438	100.0
	Mean = 2.47 Mode = 2 Median = 2.44		Mean = 3.1 Mode = 3 Median = 3.11	

more of the controls. Results of these comparisons are reported in Tables 3a for Antidesma I and 3b for Antidesma II. As seen in both tables, 75.9 percent of the total sample perceived all controls as expected (0 errors), 18.6 percent misclassified only one of the controls while 5.4 percent made two or more errors. Inspection of the row percentages of each error category for each of the different taste perceptions of the Antidesma solutions reveals that similar values were obtained. For example, if one considers the sweet responses to Antidesma I, 50.5 percent of individuals who made no errors, 51.5 percent who made one error and 55.1 percent of those who misclassified two or more controls judged this solution as sweet. Similar comparison of other perceptions for both Antidesma solutions produced similar results. Tests of association of misclassification of controls and perceptions of Antidesma results in the following values:

For Antidesma I x Errors (Misclassifications of Controls)

Cramer's V = 0.08247
Lambda (Asymmetric) = 0 with Error Dependent = 0 with Antidesma I dependent
Lambda (Symmetric) = 0

For Antidesma II x Errors

Cramer's V = 0.05469
Lambda (Asymmetric) = 0.00289 with Error Dependent = 0 with Antidesma II dependent
Lambda (Symmetric) = 0.00089

(For explanation of rationale for use of these statistics, see Appendix.)

Taste perceptions of the three PTC concentrations are reported in Table 4a. The greatest proportion of individuals judged each of these solutions as bitter (56.1-70.1 percent) or tasteless (24.2-39.2 percent) while a small number (4.7-5.7 percent) judged these as having other taste qualities (sour, salty or sweet). Application of the

Table 3a.--Comparison of Antidesma I Perceptions with Misclassifications (Errors) of Controls.

	*Count *Row % *Column % *Total %	Antidesma I Perceptions					Row Total
		Tasteless	Sour	Sweet	Bitter	Salty	
Errors	0	8	382	551	146	5	1092
		0.7	35.0	50.5	13.4	0.5	75.9
		66.7	73.9	75.3	86.9	55.6	
		0.6	26.6	38.3	10.2	0.3	
	1	2	110	138	15	3	268
		0.7	41.0	51.5	5.6	1.1	18.6
		16.7	21.3	18.9	8.9	33.3	
		0.1	7.6	9.6	1.0	0.2	
	≥ 2	2	25	43	7	1	78
		2.6	32.1	55.1	9.0	1.3	5.4
		16.7	4.8	5.9	4.2	11.1	
		0.1	1.7	3.0	0.5	0.1	
	Column Total	12	517	732	168	9	1438
		0.8	36.0	50.9	11.7	0.6	100.0

Cramer's V = 0.08247

Lambda (Asymmetric) = 0 with Error dependent

= 0 with Antidesma I dependent

Lambda (Symmetric) = 0

*These designations apply to the four values (in the order tabulated) in each error category for each perception recorded in this table. These designations are also applicable to Tables 3b, 5a-c, 6b, 9b, 12b, 15b, 18b and 24a.

Table 3b.--Comparison of Antidesma II Perceptions with Misclassifications (Errors) of Controls.

	Count Row % Column % Total %	Antidesma II Perceptions				Row Total
		Sour	Sweet	Bitter	Salty	
Errors	0	504 46.2 76.4 35.0	275 25.2 75.3 19.1	310 28.4 76.5 21.6	3 0.3 37.5 0.2	1092 75.9
	1	125 46.6 18.9 8.7	70 26.1 19.2 4.9	69 25.7 17.0 4.8	4 1.5 50.0 0.3	268 18.6
	≥ 2	31 39.7 4.7 2.2	20 25.6 5.5 1.4	26 33.3 6.4 1.8	1 1.3 12.5 0.1	78 5.4
	Column Total	660 45.9	365 25.4	405 28.2	8 0.6	1438 100.0

Cramer's V = 0.05469

Lambda (Asymmetric) = 0.00289 with Error dependent

= 0.00236 with Antidesma II dependent

Lambda (Symmetric) = 0.00089

Table 4a.--Taste Perceptions of PTC.

	PTC (Low)		PTC (Medium)		PTC (High)	
	No.	%	No.	%	No.	%
Tasteless	563	39.2	450	31.3	348	24.2
Sour	55	3.8	53	3.7	71	4.9
Sweet	2	0.1	5	0.3	1	0.09
Bitter	806	56.1	920	64.0	1008	70.1
Salty	12	0.8	10	0.7	10	0.7
Taster	60.8		68.7		75.8	
Nontaster	39.2		31.3		24.2	
Bitter	56.1		64.0		70.1	
Nonbitter	43.9		36.0		29.9	

Table 4b.--Intensities of PTC.

	PTC (Low)		PTC (Medium)		PTC (High)	
	No.	%	No.	%	No.	%
0	563	39.2	450	31.3	348	24.2
1	184	12.8	119	8.3	88	6.1
2	142	9.9	132	9.2	88	6.1
3	184	12.8	146	10.2	122	8.5
4	184	12.8	239	16.6	207	14.4
5	181	12.6	352	24.5	585	40.7
Mean	= 1.85		= 2.46		= 3.05	
Mode	= 0		= 0		= 5	
Median	= 1.35		= 2.62		= 3.85	

traditional taster-nontaster classification produced an increased frequency of tasters and a corresponding decrease in nontasters with increasing concentrations of PTC. Based on the most frequently reported concentration of PTC (81.25 mg/l) employed to determine taster-nontaster status, the frequencies of tasters was 75.8 percent and nontasters was 24.2 percent. Classification by use of the bitter-nonbitter dichotomy reveals a similar increase in bitter responders and decrease in nonbitter responders with increasing concentration. Frequencies of those types of responders at the highest PTC concentrations (81.25 mg/l) results in frequencies of 70.1 percent bitter responders and 29.9 percent nonbitter responders. With respect to intensities recorded for the different PTC concentrations, Table 4b shows that the mean intensities increased with concentration from 1.85 for the lowest to 3.05 for the highest concentration.

The relationships of PTC perceptions for each concentration and misclassification of control solutions were determined and are reported in Tables 5a, 5b and 5c. Comparisons of the row percentages for each PTC perception show no significant differences between individuals who had no misclassifications and those who made one or more errors in perceptions of controls. Values for statistical tests of association (Cramer's V and Lambda) indicated no significant associations existed.

Taste Perceptions and Age of Respondents

Comparisons of age of respondents and taste perceptions to controls and experimentals were made. For purposes of these analyses, subjects were grouped in eight age categories: (1) 7-12 yrs, (2) 13-17 yrs, (3) 18-22 yrs, (4) 23-30 yrs, (5) 31-40 yrs, (6) 41-50 yrs,

Table 5a.--Comparison of Taste Perceptions of PTC (Low Concentration) with Misclassifications (Errors) of Controls.

	Count Row % Column % Total %	PTC (Low Conc.-20.31 mg/l) Perceptions					Row Total
		Tasteless	Sour	Sweet	Bitter	Salty	
Errors	0	419	27	1	637	8	1092
		38.4	2.5	0.1	58.3	0.7	
		74.4	49.1	50.0	79.0	66.7	
		29.1	1.9	0.1	44.3	0.6	75.9
	1	106	17	1	141	3	268
		39.6	6.3	0.4	52.6	1.1	
		18.8	30.9	50.0	17.5	25.0	
		7.4	1.2	0.1	9.8	0.2	18.6
	≥ 2	38	11	0	28	1	78
		48.7	14.1	0	35.9	1.3	
		6.7	20.0	0	3.5	8.3	
		2.6	0.8	0	1.9	0.1	5.4
	Column	563	55	2	806	12	1438
	Total	39.2	3.8	0.1	56.1	0.8	100.0

Cramer's V = 0.12138

Lambda (Asymmetric) = 0 with Error dependent

= 0.01582 with PTC Low Conc. dependent

Lambda (Symmetric) = 0.01022

Table 5b.--Comparison of Taste Perceptions of PTC (Medium Concentration) with Misclassifications (Errors) of Controls.

	Count Row % Column % Total %	PTC (Medium Conc.-40.63 mg/l) Perceptions					Row Total
		Tasteless	Sour	Sweet	Bitter	Salty	
Errors	0	338	27	2	721	4	1092
		31.0	2.5	0.2	66.0	0.4	
		75.1	50.9	40.0	78.4	40.0	75.9
		23.5	1.9	0.1	50.1	0.3	
	1	85	14	2	165	2	268
		31.7	5.2	0.7	61.5	0.7	
		18.9	26.4	40.0	17.9	20.0	18.6
		5.9	1.0	0.1	11.5	0.1	
	$\geq$ 2	27	12	1	34	4	78
		34.6	15.4	1.3	43.5	5.1	
		6.0	22.6	20.0	3.7	40.0	5.4
		1.9	0.8	0.1	2.4	0.3	
	Column	450	53	5	920	10	1438
	Total	31.3	3.7	0.3	64.0	0.7	100.0

Cramer's V = 0.15510

Lambda (Asymmetric) = 0 with Error dependent

= 0 with PTC Med. Conc. dependent

Lambda (Symmetric) = 0

Table 5c.--Comparison of Taste Perceptions of PTC (High Concentration) with Misclassifications (Errors) of Controls.

	Count Row % Column % Total %	PTC (High Conc.-81.25 mg/l) Perceptions					Row Total
		Tasteless	Sour	Sweet	Bitter	Salty	
Errors	0	264	39	1	782	6	1092
		24.2	3.6	0.1	71.6	0.5	75.9
		75.9	54.9	100.0	77.6	60.0	
		18.4	2.7	0.1	54.4	0.4	
	1	65	14	0	186	3	268
		24.3	5.2	0	69.4	1.1	18.6
		18.7	19.7	0	18.5	30.0	
		4.5	1.0	0	12.9	0.2	
	$\geq$ 2	19	18	0	40	1	78
		24.4	23.1	0	51.3	1.3	5.4
		5.5	25.4	0	4.0	10.0	
		1.3	1.3	0	2.8	0.1	
	Column Total	348	71	1	1008	10	1438
		24.2	4.9	0.1	70.1	0.7	100.0

Cramer's V = 0.14706

Lambda (Asymmetric) = 0 with Error

= 0 with PTC High Conc. dependent

Lambda (Symmetric) = 0

(7) 51-60 yrs, and (8) 61-72 yrs. Table 6a shows the distribution of "correct" and "incorrect" responses to the control solutions. As can be noted, the 18-22 years and 23-30 years age groups tended to misclassify all controls with greater frequency than other age categories. Elevated misclassification frequencies are also seen in the 7-12 years group for the sour and bitter controls. This trend is further suggested by data presented in Table 6b, which compares the misclassification of controls for the different age groups. As shown, the frequencies in the "no error" category for the age groups 18-22 years and 23-30 years are 71.1 percent and 60.0 percent respectively while in the 7-12 years group, 80.2 percent made no errors. These values may be contrasted with the percentages of individuals in other age groups who perceived the controls as expected which were 88.1-100 percent. Despite these apparent tendencies for certain age groups to misclassify the controls, statistical tests revealed no significant differences in perceptions of controls due to age (Cramer's V = 0.13904, Lambda = 0).

Age related frequencies of taste perceptions of the Antidesma solutions are tabulated in Table 7a. For Antidesma I, a majority of subjects in all age groups perceived this as sweet (25.8-66.7 percent) or sour (22.2-52.6 percent). Individual percentages calculated for these perceptions for each group are not significantly different from the population average of 50.9 percent (for sweet) and 36.0 percent (for sour) nor do any apparent trends with age emerge. For bitter perceptions of Antidesma I the age groups of 7-12 years and 31-40 years had the highest frequencies of this response (20.6-20.8 percent), while for other age groups the percentage of bitter perception varied from 3.3-17.8 percent. None of these values were found to be significantly

Table 6a.--Comparison of Age of Respondent with Perception of Controls.

Age Group (years)	Sour Control				Tasteless Control				Salty Control				Bitter Control				Sweet Control			
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. 7-12 (n=96)	82	85.4	14	14.6	94	97.9	2	2.1	95	99.0	1	1.0	91	94.8	5	5.2	95	99.0	1	1.0
2. 13-17 (n=101)	93	92.1	8	7.9	101	100.0	0	0	100	99.0	1	1.0	96	95.0	5	5.0	101	100.0	0	0
3. 18-22 (n=968)	758	78.3	210	21.7	944	97.9	24	2.5	940	97.1	28	2.9	896	92.6	72	7.4	951	98.2	17	1.8
4. 23-30 (n=30)	24	80.0	6	20.0	29	96.7	1	3.3	28	93.3	2	6.7	24	80.0	6	20.0	29	96.7	1	3.3
5. 31-40 (n=97)	91	93.8	6	6.2	97	100.0	0	0	95	97.9	2	2.1	95	97.5	2	2.1	96	99.0	1	1.0
6. 41-50 (n=118)	105	89.0	13	11.0	118	100.0	0	0	116	98.3	2	1.7	115	97.8	3	2.5	118	100.0	0	0
7. 51-60 (n=19)	19	100.0	0	0	19	100.0	0	0	19	100.0	0	0	17	89.5	2	10.5	19	100.0	0	0
8. 61-72 (n=9)	9	100.0	0	0	9	100.0	0	0	9	100.0	0	0	9	100.0	0	0	9	100.0	0	0

Table 6b.--Comparison of Age of Respondent and Misclassifications (Errors) of Controls.

	Count Row % Column % Total %	Age of Respondent								Row Total
		(1) 7-12	(2) 13-17	(3) 18-22	(4) 23-30	(5) 31-40	(6) 41-50	(7) 51-60	(8) 61+	
Errors	0	77	91	688	18	88	104	17	9	1092
		7.1	8.3	63.0	1.6	8.1	9.5	1.6	0.8	
		80.2	90.1	71.1	60.0	90.7	88.1	89.5	100.0	
		5.4	6.3	47.8	1.3	6.1	7.2	1.2	0.6	75.9
	1	16	7	216	9	7	11	2	0	268
		6.0	2.6	80.6	3.4	2.6	4.1	0.7	0	
		16.7	6.9	22.3	30.0	7.2	9.3	10.5	0	
		1.1	0.5	15.0	0.6	0.5	0.8	0.1	0	18.6
	≥ 2	3	3	64	3	2	3	0	0	78
		3.8	3.8	82.1	3.8	2.6	3.8	0	0	
		3.1	3.0	6.6	10.0	2.1	2.5	0	0	
		0.2	0.2	4.5	0.2	0.1	0.2	0	0	5.4
	Column Total	96	101	968	30	97	118	19	9	1438
		6.7	7.0	67.3	2.1	6.7	8.2	1.3	0.6	100.0

Cramer's V = 0.13904

Lambda (Asymmetric) = 0 with Error dependent = 0 with Age dependent

Lambda (Symmetric) = 0

Table 7a. Comparison of Age of Respondent with Perceptions of Antidesma.

	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
(1) 7-12 (n=96)	0	0	0	0	38	39.6	46	47.9	35	36.5	15	15.6	20	20.8	33	34.4	3	3.1	2	2.1
(2) 13-17 (n=101)	0	0	0	0	33	32.7	48	47.5	52	51.5	25	24.8	16	15.8	28	27.7	0	0	0	0
(3) 18-22 (n=968)	7	0.7	0	0	316	32.6	415	42.9	552	57.0	282	29.1	87	9.0	267	27.6	6	0.6	4	0.4
(4) 23-30 (n=30)	1	3.3	0	0	15	50.0	11	36.7	13	43.3	5	16.7	1	3.3	14	46.7	0	0	0	0
(5) 31-40 (n=97)	1	1.0	0	0	51	52.6	50	51.5	25	25.8	16	16.5	20	20.6	30	30.9	0	0	1	1.0
(6) 41-50 (n=118)	3	2.5	0	0	54	45.8	77	65.3	40	33.9	16	13.6	21	17.8	24	20.3	0	0	1	0.8
(7) 51-60 (n=19)	0	0	0	0	8	42.1	11	57.9	9	47.4	6	31.6	2	10.5	2	10.5	0	0	0	0
(8) 61-72 (n=9)	0	0	0	0	2	22.2	2	22.2	6	66.7	0	0	1	11.1	7	77.8	0	0	0	0
Totals	12	0.8	0	0	517	36.0	660	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.6	8	0.6

Ad I = Antidesma I: Cramer's V = 0.12739; Lambda (Asymmetric) = 0 with age dependent = 0.0674 with Ad I dependent; Lambda (Symmetric) = 0.03827.

Ad II = Antidesma II: Cramer's V = 0.11824; Lambda (Asymmetric) = 0 with age dependent = 0.01028 with Ad II dependent; Lamba (Symmetric) = 0.00641.

different from the overall population frequency. The small numbers reported for the tasteless and salty perceptions were not conducive to analysis.

With respect to age related frequencies of perceptions of Antidesma II individuals in all age groups most often judged this solution as sour (45.9%) or bitter (28.2%) with an appreciable number (25.4 percent) reporting sweet perceptions. In all cases, with the exception of age groups 41-50 and 51-60, sweet perception frequencies were less than those of bitter. As with Antidesma I, no age trends are apparent for perception of Antidesma II nor are the frequencies of each specific perception reported for each age group significantly different from each other and from those found in the overall population.

Despite the lack of age trends for overall perceptions for Antidesma, a significant difference with age was found when the bitter-nonbitter classification for these solutions was employed. These data are reported in Table 7b. Analysis by X^2 results in a probability of less than 0.05 for both Antidesma I and Antidesma II for age categories. Examination of X^2 calculations however, reveal that for Antidesma I deviations of the age groups 1 (7-12 yrs), 3 (18-22 yrs), 5 (31-40 yrs) and 6 (41-50 yrs) made the greatest contributions to the X^2 value while for Antidesma II, greatest deviations from expected were found for the age groups 4 (23-30 yrs) and 8 (61-72 yrs). Such results again fail to substantiate definitive age trends.

Age group categories were compared with respect to their perceptions to the three concentrations of PTC and are presented in Table 8a. For the lowest concentrations of PTC, it will be noted that the overall average frequency for the tasteless perception was 39.2

Table 7b.--Comparison of Age of Respondent with Antidesma Bitter-Nonbitter Perceptions.

Age Groups (Years)	Antidesma I				Antidesma II			
	Bitter		Nonbitter		Bitter		Nonbitter	
	No.	%	No.	%	No.	%	No.	%
(1) 7-12 (n=96)	20	20.8	76	79.2	33	34.4	63	65.6
(2) 13-17 (n=101)	16	15.8	85	84.2	28	27.7	73	72.3
(3) 18-22 (n=968)	87	9.0	881	91.0	267	27.6	701	72.4
(4) 23-30 (n=30)	1	3.3	29	96.7	14	46.7	16	53.3
(5) 31-40 (n=97)	20	20.6	77	79.4	30	30.9	67	69.1
(6) 41-50 (n=118)	21	17.8	97	82.2	24	20.3	94	79.7
(7) 51-60 (n=19)	2	10.5	17	89.5	2	10.5	17	89.5
(8) 61-72 (n=9)	1	11.1	8	88.9	7	77.8	2	22.5
Totals	168	11.7	1270	88.3	405	28.2	1033	71.8
	$\chi^2_7 = 30.29$				$\chi^2_7 = 25.25$			
	$p < 0.05$				$p < 0.05$			

Table 8a.--Comparison of Age of Respondent with Perception of PTC.

Age Groups (years)	Tasteless						Sour						Sweet						Bitter						Salty					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. 7-12 (n=96)	37	38.5	29	30.2	26	27.1	11	11.5	11	11.5	10	10.4	0	0	1	1.0	0	0	46	47.9	51	53.1	56	58.3	2	2.1	4	4.2	4	4.2
2. 13-17 (n=101)	32	31.7	29	28.7	20	19.8	7	6.9	1	1.0	6	5.9	0	0	0	0	0	0	60	59.4	69	68.3	74	73.3	2	2.0	2	2.0	1	1.0
3. 18-22 (n=968)	393	40.6	311	32.1	236	24.4	29	3.0	30	3.1	41	4.2	2	0.2	4	0.4	1	0.09	539	55.7	619	63.9	687	71.0	5	0.5	4	0.4	3	0.3
4. 23-30 (n=30)	13	43.3	12	40.0	8	26.7	1	3.3	0	0	2	6.7	0	0	0	0	0	0	15	50.0	18	60.0	20	66.7	1	3.3	0	0	0	0
5. 31-40 (n=97)	35	36.1	32	33.0	26	26.8	1	1.0	2	2.1	2	2.1	0	0	0	0	0	0	61	62.9	63	64.9	69	71.1	0	0	0	0	0	0
6. 41-50 (n=118)	46	39.0	33	28.0	27	22.9	2	1.7	4	3.4	7	5.9	0	0	0	0	0	0	68	57.6	81	68.6	83	70.3	2	1.7	0	0	1	0.8
7. 51-60 (n=19)	2	10.5	2	10.5	2	10.5	3	15.8	2	10.5	2	10.5	0	0	0	0	0	0	14	73.7	15	78.9	15	78.9	0	0	0	0	0	0
8. 61-72 (n=9)	5	55.6	2	22.2	3	33.3	1	11.1	3	33.3	1	11.1	0	0	0	0	0	0	3	33.3	4	44.4	4	44.4	0	0	0	0	1	11.1
Totals	563	39.2	450	31.3	348	24.2	55	3.8	53	3.7	71	4.9	2	0.1	5	0.3	1	0.09	806	56.1	920	64.0	1008	70.1	12	0.8	10	0.7	10	0.7

PTC Low = 20.31 mg/l: Cramer's V = 0.09486; Lambda (Asymmetric) = 0 with age dependent = 0.00316 with PTC (Low) dependent; Lambda (Symmetric) = 0.00181.

PTC Med = 40.63 mg/l: Cramer's V = 0.11603; Lambda (Asymmetric) = 0 with age dependent = 0 with PTC (Med) dependent; Lambda (Symmetric) = 0.

PTC High = 81.25 mg/l: Cramer's V = 0.09507; Lambda (Asymmetric) = 0.00213 with age dependent = 0 with PTC (High) dependent; Lambda (Symmetric) = 0.00111.

percent and that the frequency of nontasters varied from 10.5 percent (ages 51-60) to 43.3 percent (ages 23-30). These two extreme frequencies in the tasteless category represented only a small number of subjects however. Frequencies for the bitter perception ranged from 33.3 percent (three of the nine subjects in age group 61-72 years) to 62.9 percent (ages 31-40 years) with an average bitter frequency of 56.1 percent. While the overall frequency of sour perception was 3.8 percent, age groups which showed the greatest tendency to judge this PTC concentration as sour were groups 1 (7-12 yrs), 7 (51-60 yrs) and 8 (61-72 yrs) reporting frequencies of sour greater than 10 percent. Both individuals who perceived this as sweet were in age group 3 (18-22 years). Additionally, there were 12 subjects (0.8 percent) who judged this solution as salty. Cramer's V and Lambda statistical tests of association however, revealed no significant differences for age groups for this lowest PTC concentration.

For the medium concentration of PTC, the frequencies of perceptions of tasteless varied from 10.5 percent (ages 51-60) to 40.0 percent (ages 23-30) with an overall frequency of 31.3 percent for this perception. Of the five individuals who judged this solution as sweet, four were in age group 3 (18-22 yrs) and one in group 1 (7-12 yrs). The average frequency of the sour response was 3.7 percent with age groups 1, 7 and 8 reporting a sour frequency greater than 10 percent. The percentages of the bitter perception varied from 44.4-78.9 percent while the average frequency was 64.0 percent and ten individuals (0.7 percent) recorded salty perceptions. As reported for the previous PTC concentration, calculations of statistical tests for the medium concentration of PTC show no significant associations with age.

Table 8a also shows age related perceptions reported for the high concentration of PTC used. As reported previously, the average frequency of nontasters (tasteless) decreased to 24.2 percent but ranged from 10.5 percent for age group 7 (51-60 yrs) to 33.3 percent for group 8 (61-72 yrs). While the average frequency of sour responders for this solution was 4.9 percent, age groups which reported a sour frequency of greater than 10 percent were groups 1 (7-12 yrs), 7 (51-60 yrs) and 8 (61-72 yrs). Only one individual judged this solution as sweet (age group 3) and ten subjects reported salty perceptions. Frequencies of bitter responders varied from 44.4 percent for age group 8 to 78.9 percent for age group 7 with an overall average frequency of 70.1 percent. No significant associations were found for the different perceptions of the PTC high concentration with age.

To facilitate subsequent correlations, age related PTC perceptions were compared with respect to taster-nontaster and bitter-nonbitter status and are reported in Table 8b. For the low concentrations of PTC taster frequencies ranged from 44.4 percent for age group 8 (61-72 yrs) to 89.5 percent for age group 7 (51-60 yrs) with an average overall frequency of tasters of 60.8 percent. For the medium PTC concentration, minimum (60.0 percent) and maximum (89.5 percent) taster frequencies were obtained for age group 4 (23-30 yrs) and 7 (51-60 yrs) and an average frequency of 68.7 percent. Corresponding minimum (66.7 percent) and maximum (89.5 percent) taster values for the high concentration of PTC were found in age group 8 (61-72 yrs) and 7 (51-60 yrs) and the average taster frequency was 75.8 percent. Age differences with respect to PTC taster-nontaster status were not statistically significant ($p > 0.05$).

Table 8b.--Comparison of Age of Respondent with PTC Taster-Nontaster and Bitter-Nonbitter Perceptions.

Age Groups (years)	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. 7-12 yrs. (n=96)	59	61.5	67	69.8	70	72.9	37	38.5	29	30.2	26	27.1	46	47.9	51	53.1	56	58.3	50	32.1	45	46.9	40	41.7
2. 13-17 (n=101)	69	68.1	72	71.3	81	80.2	32	31.7	29	28.7	20	19.8	60	59.4	69	68.3	74	73.3	41	40.6	32	31.7	27	26.7
3. 18-22 (n=968)	575	59.4	657	67.9	732	75.6	393	40.6	311	32.1	236	24.4	539	55.7	619	63.9	687	71.0	429	44.3	349	36.1	281	29.0
4. 23-30 (n=30)	17	56.7	18	60.0	22	73.3	13	43.3	12	40.0	8	26.7	15	50.0	18	60.0	20	66.7	15	50.0	12	40.0	10	33.3
5. 31-40 (n=97)	62	63.9	65	67.0	71	73.2	35	36.1	32	33.0	26	26.8	61	62.9	63	64.9	69	71.1	36	37.1	34	35.1	28	28.9
6. 41-50 (n=118)	72	61.0	85	72.0	91	77.1	46	39.0	33	28.0	27	22.9	68	57.6	81	68.6	83	70.3	50	42.4	37	31.6	35	29.7
7. 51-60 (n=19)	17	89.5	17	89.5	17	89.5	2	10.5	2	10.5	2	10.5	14	73.7	15	78.9	15	78.9	5	26.3	4	21.1	4	21.1
8. 61-72 (n=9)	4	44.4	7	77.8	6	66.7	5	55.6	2	22.2	3	33.3	3	33.3	4	44.4	4	44.4	6	66.7	5	55.6	5	55.6
Totals	875	60.8	988	68.7	1090	75.8	563	39.2	450	31.3	348	24.2	806	56.1	920	64.0	1008	70.1	632	43.9	518	36.0	430	29.9

PTC Low = 20.31 mg/l: $\chi^2_7 = 11.58$, $p > 0.05$. $\chi^2_7 = 9.94$, $p > 0.05$.

PTC Med = 40.63 mg/l: $\chi^2_7 = 6.73$, $p > 0.05$. $\chi^2_7 = 10.54$, $p > 0.05$.

PTC High = 81.25 mg/l: $\chi^2_7 = 4.12$, $p > 0.05$. $\chi^2_7 = 10.97$, $p > 0.05$.

Table 8b also shows that for the three concentrations of PTC, low, medium and high, the average bitter responders were 56.1 percent, 64.0 percent and 70.1 percent respectively. Comparisons of PTC perceptions with age shows that for each concentration of PTC the youngest subjects (group 1, 7-12 yrs) and oldest subjects (group 8, 61-72 yrs) were found to have the lowest frequencies of bitter responders. Corresponding frequencies for other age groups were varied with no discernible age trends. Indeed, X^2 analysis shows that with respect to age the bitter-nonbitter PTC status for the concentrations used was not significant ($p > 0.05$).

Taste Perceptions and Sex of Respondents

As reported previously, taste perceptions of 620 males and 818 females were assessed. Perceptions of the control solutions by sex are reported in Table 9a. In all cases except for the sweet control, females were less likely to report "incorrect" (misclassifications) perceptions when compared to males. The greatest differences of incorrect perceptions between the sexes appears in the misclassification of the bitter control in which the "error" rate for males (9.5 percent) is over two times that of females (4.4 percent). For the sour control, where overall misclassifications were more frequent, males were about 80 percent more likely to incorrectly perceive this control (Error rate was 20.2 percent for males and 16.1 percent for females). In spite of these apparent male-female differences in perceptions of the controls, statistical tests of associations for error categories (0, 1 and 2) as reported in Table 9b, shows no significant associations of misperceptions with sex of respondents.

Table 9a.--Comparison of Sex of Respondent and Perception of Controls.

	Males (n=620)		Females (n=818)	
	No.	%	No.	%
Sour Control				
Correct	495	79.8	686	83.9
Incorrect	125	20.2	132	16.1
(Overall frequency of Sour Control misclassification = 17.9%)				
Tasteless Control				
Correct	604	97.4	807	98.7
Incorrect	16	2.6	11	1.3
(Overall frequency of Tasteless Control misclassification = 1.9%)				
Salty Control				
Correct	604	97.4	798	97.6
Incorrect	16	2.6	20	2.4
(Overall frequency of Salty Control misclassification = 2.5%)				
Bitter Control				
Correct	561	90.5	782	95.6
Incorrect	59	9.5	36	4.4
(Overall frequency of Bitter Control misclassification = 6.6%)				
Sweet Control				
Correct	613	98.9	805	98.4
Incorrect	7	1.1	13	1.6
(Overall frequency of Sweet Control misclassification = 1.4%)				

Table 9b.--Comparison of Sex of Respondent with Misclassification of Controls.

	Count Row % Column % Total %	Sex of Respondent		Row Total
		Males	Females	
Errors	0	454	638	1092
		41.6	58.4	
		73.2	78.0	75.9
		31.6	44.4	
	1	118	150	268
		44.0	56.0	
		19.0	18.3	18.6
		8.2	10.4	
	≥ 2	48	30	78
		61.5	38.5	
		7.7	3.7	5.4
		3.3	2.1	
	Column Total	620	818	1438
		43.1	56.9	100.0

Cramer's V = 0.09113

Lambda (Asymmetric) = 0 with Error dependent

= 0.02903 with Sex dependent

Lambda (Symmetric) = 0.01863

Sex differences with respect to perceptions of Antidesma are tabulated in Table 10a. For Antidesma I, proportions of males and females in each taste perception category were quite similar in that the differences between the sexes ranged from 0-2.1 percent. For Antidesma II, although a wider range of taste perception differences for males and females was found (0-5.0 percent) such differences were not striking. Thus for both Antidesma I and Antidesma II, overall frequencies for each perception were not significantly different when male-female comparisons were made ($p > 0.05$).

Further analysis of sex differences for Antidesma perceptions as reported in Table 10b produced dissimilar results. As can be observed, comparison of sex of respondent with respect to bitter and nonbitter perceptions revealed that for Antidesma I, no significant sex differences were obtained ($\chi_1^2 = 1.519$, $p > 0.05$). For Antidesma II however, bitter-nonbitter perceptions of males and females are statistically significant ($\chi_1^2 = 4.315$, $p < 0.05$).

Frequencies of taste responses for each of the three concentrations of PTC by sex are reported in Table 11a. These data show that for each PTC concentration, a greater proportion of males found these solutions tasteless, sour or salty when compared to females. Conversely, females were more likely to report bitter or sweet perceptions than males. The overall perceptions for the different sexes were not significant (see Cramer's V and Lambda values).

Results compiled in Table 11b show the proportions of males and females who were classified as PTC tasters or nontasters as well as those who were bitter and nonbitter responders. It is apparent from these data, that for all PTC concentrations, a greater proportion of

Table 10a. Comparison of Sex of Respondent with Perceptions of Antidesma.

	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Males (n=620)	4	0.6	0	0	224	36.1	289	46.6	323	52.1	170	27.4	65	10.5	157	25.3	4	0.6	4	0.6
Females (n=818)	8	1.0	0	0	293	35.8	371	45.4	409	50.0	195	23.8	103	12.6	248	30.3	5	0.6	4	0.5
Differences in %		0.4		0		0.3		1.2		2.1		3.6		2.1		5.0		0		0.1

Ad I: $\chi^2_4 = 2.136$, $p > 0.05$ Ad II: $\chi^2_3 = 5.214$, $p > 0.05$

Table 10b. Comparison of Sex of Respondent with Antidesma Bitter-Nonbitter Status.

	Antidesma I				Antidesma II			
	Bitter		Nonbitter		Bitter		Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Males (n=620)	65	10.5	555	89.5	157	25.3	463	74.7
Females (n=818)	103	12.6	715	87.4	248	30.3	570	69.7
Total	168	11.7	1270	88.3	405	28.2	1033	71.8
	$\chi^2_1 = 1.519$, $p > 0.05$				$\chi^2_1 = 4.351$, $p < 0.05$			

Table 11a.--Comparison of Sex of Respondent and Perceptions of PTC.

	Tasteless						Sour						Sweet						Bitter						Salty					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Males (n=620)	256	41.3	204	32.9	154	24.8	31	5.0	25	4.0	39	6.3	0	0	1	0.2	0	0	324	52.3	384	61.9	421	67.9	9	1.5	6	1.0	6	1.0
Females (n=818	307	37.5	246	30.1	194	23.7	24	2.9	28	3.4	32	3.9	2	0.2	4	0.5	1	0.09	482	58.9	536	65.5	587	71.8	3	0.4	4	0.5	4	0.5

PTC Low (20.31 mg/l): Cramer's V = 0.10040
Lambda (Asymmetric) = 0.02097 with sex dependent
= 0 with PTC low dependent
Lambda (Symmetric) = 0.01038

PTC Med (40.63 mg/l): Cramer's V = 0.05417
Lambda (Asymmetric) = 0.00323 with sex dependent
= 0 with PTC med dependent
Lambda (Symmetric) = 0.00176

PTC High (81.25 mg/l): Cramer's V = 0.06923
Lambda (Asymmetric) = 0.01452 with sex dependent
= 0.00321 with PTC high dependent
Lambda (Symmetric) = 0.02650

Table 11b.--Comparison of Sex of Respondent and PTC Taster-Nontaster and Bitter-Nonbitter Status.

	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Males (n=620)	364	58.7	416	67.1	466	75.2	256	41.3	204	32.9	154	24.8	324	52.3	384	61.9	421	67.9	296	47.7	236	38.1	198	32.1
Females (n=818)	511	62.5	572	69.9	624	76.3	307	37.5	246	30.1	194	23.7	482	58.9	536	65.5	587	71.8	336	41.1	282	34.5	231	28.2
Total	875	60.8	988	68.7	1090	75.8	563	39.2	450	31.3	348	24.2	806	56.1	920	64.0	1008	70.1	632	43.9	518	36.0	430	29.9

PTC Low (20.31 mg/1) - $\chi_1^2 = 2.094$, $p > 0.05$ $\chi_1^2 = 6.364$, $p < 0.05$

PTC Med (40.63 mg/1) - $\chi_1^2 = 1.314$, $p > 0.05$ $\chi_1^2 = 1.972$, $p > 0.05$

PTC High (81.25 mg/1) - $\chi_1^2 = 0.242$, $p > 0.05$ $\chi_1^2 = 2.503$, $p > 0.05$

females was found to be tasters and more often perceived each PTC solution as bitter when compared to males. No significant differences were found between the sexes however, for any of the PTC concentrations when the taster-nontaster classification was employed. A similar lack of significant sex differences was found for bitter-nonbitter responders for the medium and high PTC concentrations. However, these responses to the low concentration of PTC did result in significant differences between sexes ($\chi_1^2 = 6.364$, $p < 0.05$).

Taste Perceptions and Race of Respondents

Each subject participating in this study assigned themselves to one of six racial/ethnic group categories (White/Caucasian, Black/Afro Americans, Chicano/Mexican American, Spanish American/Hispanic, American Indian or Asian/Pacific Islander). Comparison of perceptions of controls by racial groupings are tabulated in Table 12a. Inspection of these data shows little overall racial differences in expected perceptions of these solutions. It will be also noted that in instances of apparent striking racial differences from the average "correct-incorrect" frequencies (e.g., Spanish American/Hispanic perceptions of the bitter control) small numbers of individuals in these groups appear to be responsible for the deviations. Further substantiation of lack of racial differences in perceptions of controls is shown by data reported in Table 12b in which misclassifications of controls are compared by race for each error category. As seen, racial frequencies for these error categories are comparable except in cases where racial groupings contained small numbers of subjects. Statistical tests of association

Table 12a.--Comparison of Race of Respondent and Perceptions of Controls.

Race/Ethnic Group	Sour Control				Tasteless Control				Salty Control				Bitter Control				Sweet Control			
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. White Caucasian (n=1213)	986	81.3	227	18.7	1190	98.1	23	1.9	1185	97.7	28	2.3	1137	93.7	76	6.3	1196	98.6	17	1.4
2. Black/ Afro Am. (n=198)	170	85.9	28	14.1	194	98.0	4	2.0	192	97.0	6	3.0	182	91.9	16	8.1	196	99.0	2	1.0
3. Chicano/ Mexican Am. (n=13)	13	100.0	0	0	13	100.0	0	0	11	84.6	2	5.4	12	92.3	1	7.7	13	100.0	0	0
4. Spanish Am./ Hispanic (n=6)	5	83.3	1	16.7	6	100.0	0	0	6	100.0	0	0	4	66.7	2	33.3	6	100.0	0	0
5. Am. Indian (n=1)	1	100.0	0	0	1	100.0	0	0	1	100.0	0	0	1	100.0	0	0	1	100.0	0	0
6. Asian (n=7)	6	85.7	1	14.3	7	100.0	0	0	7	100.0	0	0	7	100.0	0	0	6	85.7	1	14.3
Totals	1181	82.1	257	17.9	1411	98.1	27	1.9	1402	97.5	36	2.5	1343	93.4	95	6.6	1418	98.6	20	1.4

Table 12b.--Comparison of Race of Respondent and Misclassification (Errors) of Controls.

	Count Row % Column % Total %	Race of Respondent						Row Total
		White/ (1)Causasian	Black/ (2)Afro American	Chicano/ (3)Mexican Am.	Spanish Am./ (4)Hispanic	American (5)Indian	Asian/ (6)Pac. Islander	
Errors	0	919	154	10	3	1	5	1092
		84.2	14.1	0.9	0.3	0.1	0.5	
		75.8	77.8	76.9	50.0	100.0	71.4	75.9
		63.9	10.7	0.7	0.2	0.1	0.3	
	1	225	35	3	3	0	2	268
		84.0	13.1	1.1	1.1	0	0.7	
		18.5	17.7	23.1	50.0	0	28.6	18.6
		15.6	2.4	0.2	0.2	0	0.1	
	≥ 2	69	9	0	0	0	0	78
		88.5	11.5	0	0	0	0	
		5.7	4.5	0	0	0	0	5.4
		4.8	0.6	0	0	0	0	
	Column Total	1213	198	13	6	1	7	1438
		84.4	13.8	0.9	0.4	0.1	0.5	100.0

Cramer's V = 0.04786

Lambda (Asymmetric) = 0 with Error dependent = 0 with Race dependent

Lambda (Symmetric) = 0

confirmed lack of significant association of race and errors for perceptions of control.

Table 13a reports the perceptions of the Antidesma solutions by race. For Antidesma I, where perceptions of tasteless and salty were the lowest responses reported, only whites and blacks are represented. In general, a greater proportion of individuals of all races (except Chicano) judged this solution as sweet with an average frequency of 50.9 percent. Racial frequencies for the sour response ranged from 26.8 percent for Asians to 46.2 percent for Chicanos. (Note: Sample size for these groups are small.) For the bitter perceptions of Antidesma I, none of the 7 Spanish Americans, 6 Asians nor the single American Indian reported this response. This may be contrasted with the 3 Chicanos (23.1 percent), 53 Blacks (26.8 percent) and 112 whites (9.2 percent) who reported bitter perceptions. Cramer's V and Lambda statistics indicate no overall significant associations of Antidesma I perceptions with race. With respect to race related perceptions for Antidesma II, Table 13a shows that most often racial groups judged this solution as sour (average frequency was 45.9 percent). Exceptions to this generalization occurred for Blacks and the single American Indian subject. As can be seen, over one half (50.5 percent) of Blacks and the American Indian perceived Antidesma II as bitter as compared to bitter frequencies of 14.3-24.5 percent for the other racial groups. Sweet perceptions for whites and blacks were 27.4 percent and 13.1 percent respectively while this perception reported by other racial groups yielded 0-50 percent due to small numbers of subjects. As with Antidesma I no significant overall associations of race and perceptions of Antidesma II were found.

Table 13a.--Comparison of Race of Respondent with Perceptions of Antidesma.

Race/Ethnic Group	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. White/ Caucasian (n=1213)	9	0.7	0	0	456	37.6	578	47.7	632	52.1	332	27.4	112	9.2	297	24.5	4	0.3	6	0.5
2. Black/ Afro Am. (n=198)	3	1.5	0	0	53	26.8	70	35.4	84	42.4	26	13.1	53	26.8	100	50.5	5	2.5	2	1.0
3. Chicano/ Mexican Am. (n=3)	0	0	0	0	6	46.2	7	53.8	4	30.8	1	7.7	3	23.1	5	38.5	0	0	0	0
4. Spanish Am./ Hispanic (n=6)	0	0	0	0	0	0	2	33.3	6	100.0	3	50.0	0	0	1	16.7	0	0	0	0
5. Am. Indian (n=1)	0	0	0	0	0	0	0	0	1	100.0	0	0	0	0	1	100.0	0	0	0	0
6. Asian (n=7)	0	0	0	0	2	28.6	3	42.9	5	71.4	3	42.9	0	0	1	14.3	0	0	0	0
Totals	12	0.8	0	0	517	36.0	660	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.6	8	0.6

Ad I = Antidesma I: Cramer's V = 0.11736, Lambda (Asymmetric) = 0.00444 with Race Dependent = 0.00283 with Ad I Dependent
Lambda (Symmetric) = 0.00322

Ad II = Antidesma II: Cramer's V = 0.12662, Lambda (Asymmetric) = 0 with Race Dependent = 0.04113 with Ad II Dependent
Lambda (Symmetric) = 0.03190

Because of the relatively small sample sizes of several racial categories, subsequent analyses of taste perceptions of Antidesma and PTC by race were restricted to the white and black racial groups. (General frequency data however is presented for all racial groups sampled.) Table 13b presents racial perceptions of Antidesma I and II when classified as bitter and nonbitter. As shown, the bitter perception of Antidesma I for Blacks was nearly three times that of Whites (26.8 percent versus 9.2 percent) and for Antidesma II, Blacks were more than twice as likely to perceive this solution as bitter when compared to Whites (50.5 percent versus 24.5 percent). These differences are shown to be highly significant by Chi-square analysis ($p < 0.05$).

Overall racial perceptions of the three PTC concentrations are reported in Table 14a. Based on the indicated statistical treatments, no significant associations with race were established for any of the concentrations of PTC. It will be further noted however, that for the major racial categories represented, for each concentration Blacks were less likely to judge PTC as tasteless but more likely to perceive these as sour or bitter when compared to Whites. Sweet and salty responses for these groups were similar although small numbers of subjects recording these perceptions prohibited precise generalizations.

Comparisons of racial perceptions of PTC with respect to the taster-nontaster and bitter-nonbitter dichotomies are presented in Table 14b. Taster frequencies ranged from 57.1-100 percent for all PTC concentrations (extreme values were obtained from the smaller racial groups). When White-Black taster frequencies are compared, the differences between these groups increase with concentration. Thus, at the low concentration, values obtained were 60.6 percent for Whites and 62.1

Table 13b.--Comparison of Race of Respondent with Bitter-Nonbitter Antidesma Perceptions.

Race/Ethnic Group	Antidesma I				Antidesma II			
	Bitter		Nonbitter		Bitter		Nonbitter	
	No.	%	No.	%	No.	%	No.	%
White/Caucasian (n=1213)	112	9.2	1101	90.8	297	24.5	916	75.5
Black/ Afro-American (n=198)	53	26.8	145	73.2	100	50.5	98	49.5
Chicano/ Mexican Am. (n=13)	3	23.1	10	76.9	5	38.5	8	61.5
Spanish Am./ Hispanic (n=6)	0	0	6	100.0	1	16.7	5	83.3
Am. Indian (n=1)	0	0	1	100.0	1	100.0	0	0
Asian (n=7)	0	0	7	100.0	1	14.3	6	85.7
Total	168	11.6	1270	88.4	405	28.2	1033	71.8

Analysis of White/Caucasian and Black/Afro-Americans Antidesma responses

Antidesma I: $\chi^2_1 = 50.63$, $p < 0.05$

Antidesma II: $\chi^2_1 = 56.97$, $p < 0.05$

Table 14a.--Comparison of Race of Respondent with Perception of PTC.

Race/Ethnic Group	Tasteless						Sour						Sweet					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. White/ Caucasian (n=1213)	478	39.4	391	32.2	304	25.1	41	3.4	37	3.1	51	4.2	1	0.1	4	0.3	1	0.1
2. Black/ Afro Am. (n=198)	75	37.9	50	25.3	35	17.7	10	5.1	12	6.1	16	8.1	1	0.5	1	0.5	0	0
3. Chicano/ Mexican Am. (n=13)	5	38.5	5	38.5	5	38.5	3	23.1	1	7.7	1	7.7	0	0	0	0	0	0
4. Spanish Am./ Hispanic (n=6)	2	33.3	1	16.7	1	16.7	0	0	1	16.7	1	16.7	0	0	0	0	0	0
5. Am. Indian (n=1)	0	0	0	0	0	0	1	100.0	1	100.0	1	100.0	0	0	0	0	0	0
6. Asian (n=7)	3	42.9	3	42.9	3	42.9	0	0	1	14.3	1	14.3	0	0	0	0	0	0
Totals	563	39.2	450	31.3	348	24.2	55	3.8	53	3.7	71	4.9	2	0.1	5	0.3	1	0.1

Race/Ethnic Group	Bitter						Salty					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. White/ Caucasian (n=1213)	681	56.1	773	63.7	850	70.1	12	1.0	8	0.7	7	0.6
2. Black/ Afro Am. (n=198)	112	56.6	133	67.2	145	73.2	0	0	2	1.0	2	1.0
3. Chicano/ Mexican Am. (n=13)	5	38.5	7	53.8	7	53.8	0	0	0	0	0	0
4. Spanish Am./ Hispanic (n=6)	4	66.7	4	66.7	3	50.0	0	0	0	0	1	16.7
5. Am. Indian (n=1)	0	0	0	0	0	0	0	0	0	0	0	0
6. Asian (n=7)	4	57.1	3	42.9	3	42.9	0	0	0	0	0	0
Totals	806	56.1	920	64.0	1008	70.1	12	0.8	10	0.7	10	0.7

PTC Low (20.31 mg/l): Cramer's V = 0.08856; Lambda (Asymmetric) = 0 with Race dependent, = 0.00859 with PTC Low dependent; Lambda (Symmetric) = 0.00117.

PTC Med (40.63 mg/l): Cramer's V = 0.08470; Lambda (Asymmetric) = 0 with Race dependent, = 0.00193 with PTC Med dependent; Lambda (Symmetric) = 0.01013.

PTC High (81.25 mg/l): Cramer's V = 0.10081; Lambda (Asymmetric) = 0 with Race dependent, = 0.00233 with PTC High dependent; Lambda (Symmetric) = 0.00153.

Table 14b.--Comparison of Race of Respondent and PTC Taster-Nontaster and Bitter-Nonbitter Status.

Race/Ethnic Group	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. White/ Caucasian (n=1213)	735	60.6	822	67.8	909	74.9	478	39.4	391	32.2	304	25.1	681	56.1	773	63.7	850	70.1	532	43.9	440	36.3	363	29.9
2. Black/ Afro Am. (n=198)	123	62.1	148	74.7	163	82.3	75	37.9	50	25.3	35	17.7	112	56.6	133	67.2	145	73.2	86	43.4	65	32.8	53	26.8
3. Chicano/ Mexican Am. (n=13)	8	61.5	8	61.5	8	61.5	5	38.5	5	38.5	5	38.5	5	38.5	7	53.8	7	53.8	8	61.5	6	46.2	6	46.2
4. Spanish Am./ Hispanic (n=6)	4	66.7	5	83.3	5	83.3	2	33.3	1	16.7	1	16.7	4	66.7	4	66.7	3	50.0	2	33.3	2	33.3	3	50.0
5. Am. Indian (n=1)	1	100.0	1	100.0	1	100.0	0	0	0	0	0	0	0	0	0	0	0	0	1	100.0	1	100.0	1	100.0
6. Asian (n=7)	4	57.1	4	57.1	4	57.1	3	42.9	3	42.9	3	42.9	4	57.1	3	42.9	3	42.9	3	42.9	4	57.1	4	57.1
Totals	875	60.8	988	68.7	1090	75.8	563	39.2	450	31.3	348	24.2	806	56.1	920	64.0	1008	70.1	632	43.9	518	36.0	430	29.9

Analysis of White/Caucasian and Black/Afro Americans PTC Responses.

PTC Low (20.31 mg/l): $\chi_1^2 = 0.168$, $p > 0.05$.

PTC Med (40.63 mg/l): $\chi_1^2 = 3.861$, $p < 0.05$.

PTC High (81.25 mg/l): $\chi_1^2 = 5.085$, $p < 0.05$.

PTC Low: $\chi_1^2 = 0.013$, $p > 0.05$.

PTC Med: $\chi_1^2 = 0.878$, $p > 0.05$.

PTC High: $\chi_1^2 = 1.112$, $p > 0.05$.

percent for Blacks (difference 1.5 percent) while for the medium PTC concentration these values are 67.8 percent and 74.7 percent for a difference of 6.9 percent. A 7.4 percent taster difference (74.9 percent versus 82.3 percent) for these racial groups is observed at the high PTC concentration. These differential frequencies are significant for both the medium and high concentrations of PTC ($p < 0.05$). Table 14b also shows that when comparing bitter-nonbitter PTC responses of Whites and Blacks, no significant differences are observed ($p > 0.05$) for any of the PTC concentrations.

Taste Perceptions and Smoking Status of Respondents

Data comparing the taste perceptions of control solutions for smokers and nonsmokers are compiled in Table 15a. The nonsmokers who constituted the majority of subjects surveyed (82.1 percent) were found to misclassify the sour and sweet controls with slightly greater frequency while smokers tended to misperceive the tasteless, salty and bitter controls more often. That these small differences were not significant can be seen from results presented in Table 15b in which error categories are compared. The overall predilections for "correct" or "incorrect" classification of controls are similar in both smokers and nonsmokers with no significant error associations observed for these groups as evidenced by the Cramer's V and Lambda values.

A similar lack of significant difference of taste perceptions of Antidesma between smokers and nonsmokers can be noted from data tabulated in Table 16a. Differences between these groups ranged from 0.1 to 1.0 percent for Antidesma I and 0 to 3.5 percent for Antidesma II. Such differences when analyzed by statistical tests show no

Table 15a.--Comparison of Smoking Status of Respondent and Perception of Controls.

	Sour Control				Tasteless Control				Salty Control				Bitter Control				Sweet Control			
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Smokers (n=258)	216	83.7	42	16.3	248	96.1	10	3.9	250	96.9	8	3.1	239	92.6	19	7.4	258	100.0	0	0
Nonsmokers (n=1180)	965	81.8	215	18.2	1163	98.6	17	1.4	1152	97.6	28	2.4	1104	93.6	76	6.4	1160	93.8	20	1.7
Total	1181	82.1	257	17.9	1411	98.1	27	1.9	1402	97.5	36	2.5	1343	93.4	95	6.6	1418	98.6	20	1.4

Table 15b.--Comparison of Smoking Status of Respondent and Misclassification of Controls.

	Count Row % Column % Total %	Smoking Status		Row Total
		Smoker	Nonsmoker	
Errors	0	192	900	1092
		17.6	82.4	
		74.4	76.3	75.9
		13.4	62.6	
	1	54	214	268
		20.1	79.9	
		20.9	18.1	18.6
		3.8	14.9	
	≥ 2	12	66	78
		15.4	84.6	
		4.7	5.6	5.4
		0.8	4.6	
	Column Total	258	1180	1438
		17.9	82.1	100.0

Cramer's V = 0.03040

Lambda (Asymmetric) = 0 with Error dependent

= 0 with Smoking Status dependent

Lambda (Symmetric) = 0

Table 16a.--Comparison of Smoking Status of Respondent with Perceptions of Antidesma.

	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Smokers (n=258)	3	1.2	0	0	95	36.8	111	43.0	131	50.8	71	27.5	29	11.2	76	29.5	0	0	0	0
Nonsmokers (n=1180)	9	0.8	0	0	422	35.8	549	46.5	601	50.9	294	24.9	139	11.8	329	27.9	9	0.8	8	0.7
Total	12	0.8	0	0	517	36.0	660	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.06	8	0.6
Differences in Percent	0.4		0		1.0		3.5		0.1		2.6		0.6		1.6		0.8		0.7	

Antidesma I: Cramer's V = 0.04164
Lambda (Asymmetric) = 0 with Smoking Status dependent,
= 0 with Antidesma I dependent
Lambda (Symmetric) = 0

Antidesma II: Cramer's V = 0.04618
Lambda (Asymmetric) = 0 with Smoking Status dependent,
= 0 with Antidesma II dependent
Lambda (Symmetric) = 0

significant associations between Antidesma perceptions and smoking status. Analogously, when these perceptions are compared with respect to the bitter-nonbitter classification as in Table 16b, smoker-nonsmoker differences were also insignificant ($p > 0.05$).

In Table 17a, comparisons of smoking status and perceptions of PTC are reported. Consistent differences between these groups were observed for the majority of taste responses. As shown, for all concentrations of PTC, smokers were more likely to find these solutions tasteless and less likely to perceive these as bitter or sour than were the nonsmokers. For sweet and salty perceptions (smallest categories) no trends could be discerned. Despite the apparent uniformity of taste perceptual differences for each of the five perceptions reported, no significant overall associations of any PTC concentration with smoking status could be confirmed.

As reported above, smokers more often judged each PTC solution as tasteless when compared to nonsmokers. When the absolute frequencies of tasters and nontasters are compared as in Table 17b, greater differences were found between smokers and nonsmokers for the low concentration of PTC. This difference was significant at the 5 percent level. For other PTC concentrations, no significant differences were observed between these two groups. When PTC bitter and nonbitter responses by smoking status are compared (Table 17b), as expected from previously discussed results, the frequencies of nonsmoker bitter responders were greater at each concentration than those of smokers. None of the differences however, were significant for any of the PTC solutions tested.

Table 16b.--Comparison of Smoking Status of Respondent and Antidesma Bitter-Nonbitter Status.

Smoking Status	Antidesma I				Antidesma II			
	Bitter		Nonbitter		Bitter		Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Smoker (n=258)	29	11.2	229	88.8	76	29.5	182	70.5
Nonsmoker (n=1180)	139	11.8	1041	88.2	329	27.9	851	72.1
Total	168	11.7	1270	88.3	405	28.2	1033	71.8

$\chi_1^2 = 0.061$, $p > 0.05$ $\chi_1^2 = 0.26$, $p > 0.05$

Taste Perceptions and Time of Last Food Eaten (Elapsed Time) By Respondents

In an effort to discover if relationships exist between taste perceptions and the time of last food eaten by subjects prior to taste sampling, respondents were grouped into seven elapsed time categories: (1) 0.1-0.9 hours, (2) 1.0-1.9 hours, (3) 2.0-2.9 hours, (4) 3.0-3.9 hours, (5) 4.0-4.9 hours, (6) 5.0-9.9 hours and (7) 10.0 hours or more. These analyses included 1,425 subjects since thirteen individuals failed to record the time of the last food eaten. When elapsed time is compared with respect to perceptions of controls (Table 18a), frequencies of misperceptions of these solutions are comparable throughout each elapsed time category. When the misclassification error rates were analyzed by these elapsed time groupings no significant associations were uncovered (see Table 18b).

Table 17a.--Comparison of Smoking Status of Respondent with Perception of PTC.

Smoking Status	Tasteless						Sour						Sweet					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Smoker	115	44.6	88	34.1	68	26.4	7	2.7	7	2.7	12	4.7	1	0.4	1	0.4	0	0
Nonsmoker	448	38.0	362	30.7	280	23.7	48	4.1	46	3.9	59	5.0	1	0.09	4	0.3	1	0.09
Totals	563	39.2	450	31.3	348	24.2	55	3.8	53	3.7	71	4.9	2	0.2	5	0.3	1	0.09

Smoking Status	Bitter						Salty					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Smoker	133	51.6	161	62.4	178	69.0	2	0.8	1	0.4	0	0
Nonsmoker	673	57.0	759	64.3	830	70.3	10	0.8	9	0.8	10	0.8
Totals	806	56.1	920	64.0	1008	70.1	12	0.8	10	0.7	10	0.7

PTC Low (20.31 mg/l): Cramer's V = 0.06417; Lambda (Asymmetric) = 0 with Smoker dependent, 0 with PTC Low dependent, Lambda (Symmetric) = 0.

PTC Med (40.63 mg/l): Cramer's V = 0.03882; Lambda (Asymmetric) = 0 with Smoker dependent, 0 with PTC Med dependent, Lambda (Symmetric) = 0.

PTC High (81.25 mg/l): Cramer's V = 0.04655; Lambda (Asymmetric) = 0 with Smoker dependent, 0 with PTC High dependent, Lambda (Symmetric) = 0.

Table 17b.--Comparison of Smoking Status of Respondent and PTC Taster-Nontaster and Bitter-Nonbitter Status.

Smoking Status	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Smoker (n=258)	143	55.4	170	65.9	190	73.6	115	44.6	88	34.1	68	26.4	133	51.6	161	62.4	178	69.0	125	48.1	97	37.6	80	31.0
Nonsmoker (n=1180)	732	62.0	818	69.3	900	76.3	448	38.0	362	30.7	280	23.7	673	57.0	759	64.3	830	70.3	507	43.0	421	35.7	350	29.7
Total	875	60.8	988	68.7	1090	75.8	563	39.2	450	31.3	348	24.2	806	56.1	920	64.0	1008	70.1	632	43.9	518	36.0	430	29.9

PTC Low 20.31 mg/1): $\chi^2_1 = 3.96$, $p < 0.05$

PTC Med (40.63 mg/1): $\chi^2_1 = 1.16$, $p > 0.05$

PTC High (81.25 mg/1): $\chi^2_1 = 0.80$, $p > 0.05$

PTC Low (20.31 mg/1): $\chi^2_1 = 2.594$, $p > 0.05$

PTC Med (40.63 mg/1): $\chi^2_1 = 0.339$, $p > 0.05$

PTC High (81.25 mg/1): $\chi^2_1 = 0.185$, $p > 0.05$

Table 18a. Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) and Perception of Controls.*

Elapsed Time	Sour Control				Tasteless Control				Salty Control				Bitter Control				Sweet Control			
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
(1) 0.1-0.9 hrs. (n=263)	222	84.4	41	15.6	260	98.9	3	1.1	256	97.3	7	2.7	247	93.9	16	6.1	262	99.6	1	0.4
(2) 1.0-1.9 hrs. (n=374)	306	81.8	68	18.2	369	98.7	5	1.3	369	98.7	5	1.3	352	94.1	22	5.9	369	98.7	5	1.3
(3) 2.0-2.9 hrs. (n=262)	221	84.4	41	15.6	257	98.1	5	1.9	251	95.8	11	4.2	242	92.4	20	7.6	258	98.5	4	1.5
(4) 3.0-3.9 hrs. (n=151)	121	80.1	30	19.1	146	96.7	5	3.3	149	98.7	2	1.3	140	92.7	11	7.3	147	97.4	4	2.6
(5) 4.0-4.9 hrs. (n=60)	51	85.0	9	15.0	60	100.0	0	0	57	95.0	3	5.0	55	91.7	5	8.3	59	98.3	1	1.7
(6) 5.0-9.9 hrs. (n=88)	74	84.1	14	15.9	86	97.7	2	2.3	85	96.6	3	3.4	84	95.5	4	4.5	88	100.0	0	0
(7) 10.0 hrs. + (n=227)	178	78.1	49	21.6	221	97.4	6	2.6	222	97.8	5	2.2	213	93.8	14	6.2	222	97.8	5	2.2
Totals	1173	82.3	252	17.7	1399	98.2	26	1.8	1389	97.5	36	2.5	1333	93.5	92	6.5	1405	98.6	20	1.4

*Analysis of subjects who recorded time of last food eaten, n=1425.

Table 18b.--Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) and Misclassification (Errors) of Controls.

Count Row Pct Column Pct Total Pct	Elapsed Time (in Hours)							Row Total
	0.1-0.9	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-9.9	10.0+	
Errors								
0	209 19.3 79.5 14.7	288 26.5 77.0 20.2	203 18.7 77.5 14.2	110 10.1 72.8 7.7	45 4.1 75.0 3.2	69 6.4 78.4 4.8	161 14.8 70.9 11.3	1085 76.1
1	41 15.5 15.6 2.9	69 26.0 18.4 4.8	41 15.5 15.6 2.9	32 12.1 21.2 2.2	12 4.5 20.0 0.8	16 6.0 18.2 1.1	54 20.4 23.8 3.8	265 18.6
≥2	13 17.3 4.7 0.9	17 22.7 4.5 1.2	18 24.0 6.9 1.3	9 12.0 6.0 0.6	3 4.0 5.0 0.2	3 4.0 3.4 0.2	12 16.0 5.3 0.8	75
Column Total %	263 18.5	374 26.2	262 18.4	151 10.6	60 4.2	88 6.2	227 15.9	1425 100.0

Cramer's V = 0.06046. Lambda (Symmetric) = 0.00072.

Lambda (Asymmetric) = 0 with Error dependent, = 0.00095 with Elapsed Time dependent.

Specific taste perceptions of Antidesma solutions with respect to elapsed time are presented in Table 19a. As with perceptions of controls, no apparent elapsed time trends are presented for any of these perceptions for Antidesma I or Antidesma II. Thus, time of last food eaten is not significantly associated with Antidesma perceptions (see Cramer's V and Lambda values).

When bitter-nonbitter perceptions of Antidesma are compared by elapsed time a similar lack of perception-elapsed time trend is observed (Table 19b). Although the highest frequencies of the bitter response was seen at 4.0-4.9 hours after last food eaten for both Antidesma solutions, this difference as well as overall bitter-nonbitter differences by elapsed time were not significant.

Similar tabulations of effects of elapsed time on perceptions of PTC are reported in Table 20a. For each PTC concentration, the proportions of subjects who judged these solutions as tasteless appears to decline up to three hours while the proportion reporting bitter responses increase up to this same time. In subsequent elapsed time categories, frequencies of subjects reporting these perceptions appear to fluctuate randomly as do those of subjects who recorded other perceptions (sour, sweet and salty) across all elapsed time categories. Analyses of these overall responses reveal no significant differences with respect to elapsed time.

PTC perceptions by elapsed time were also analyzed in terms of the taster-nontaster and bitter-nonbitter classification. These data are reported in Table 20b and show the same trends for the nontasters and bitter responders as previously mentioned. When these responses are analyzed by overall elapsed time groupings, differences between

Table 19a.--Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) with Perceptions of Antidesma.

Elapsed Time	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
(1) 0.1-0.9 hrs. (n=263)	3	1.1	0	0	109	41.4	12	46.0	114	43.3	59	22.4	37	14.1	30	30.4	0	0	0	1.1
(2) 1.0-1.9 hrs. (n=374)	4	1.1	0	0	134	35.8	186	49.7	182	48.7	86	23.0	49	13.1	100	26.7	5	1.3	2	0.5
(3) 2.0-2.9 hrs. (n=262)	1	0.4	0	0	85	32.4	127	48.5	152	58.0	62	23.7	22	8.4	72	27.5	2	0.8	1	0.4
(4) 3.0-3.9 hrs. (n=151)	0	0	0	0	67	44.4	72	47.7	71	47.0	38	25.2	13	8.6	41	27.2	0	0	0	0
(5) 4.0-4.9 hrs. (n=60)	0	0	0	0	13	21.7	24	40.0	37	61.7	16	26.7	10	16.7	19	31.7	0	0	1	1.7
(6) 5.0-9.9 hrs. (n=88)	0	0	0	0	34	38.6	39	44.3	42	47.7	23	26.1	11	12.5	25	28.4	1	1.1	1	1.1
(7) 10.0+ hrs. (n=227)	4	1.8	0	0	71	31.3	88	38.8	126	55.5	75	33.0	26	11.5	64	28.2	0	0	0	0
Totals	12	0.8	0	0	513	36.0	657	46.1	724	50.8	359	25.2	168	11.8	401	28.1	8	0.6	8	0.6

Antidesma I: Cramer's V = 0.08517
Lambda (Asymmetric) = 0 with Elapsed Time dependent = 0 with Antidesma I dependent
Lambda (Symmetric) = 0

Antidesma II: Cramer's V = 0.06637
Lambda (Asymmetric) = 0 with Elapsed Time dependent = 0 with Antidesma II dependent
Lambda (Symmetric) = 0

Table 19b.--Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) with Antidesma Bitter-Nonbitter Status.

Elapsed Time	Antidesma I				Antidesma II			
	Bitter		Nonbitter		Bitter		Nonbitter	
	No.	%	No.	%	No.	%	No.	%
1. 0.1-0.9 hrs. (n=263)	37	14.1	226	85.9	80	30.4	183	69.6
2. 1.0-1.9 hrs. (n=374)	49	13.1	325	86.9	100	26.7	274	73.3
3. 2.0-2.9 hrs. (n=262)	22	8.4	240	91.6	72	27.5	190	72.5
4. 3.0-3.9 hrs. (n=151)	13	8.6	138	91.4	41	27.2	110	72.8
5. 4.0-4.9 hrs. (n=60)	10	16.7	50	83.3	19	31.7	41	68.3
6. 5.0-9.9 hrs. (n=88)	11	12.5	77	87.5	25	28.4	63	71.6
7. 10.0+ hrs. (n=227)	26	11.5	201	88.5	64	28.2	163	71.8
Totals	168	11.8	1257	88.2	401	28.1	1024	71.9

Antidesma I: $\chi^2_6 = 7.739$, $p > 0.05$

Antidesma II: $\chi^2_6 = 1.54$, $p > 0.05$

Table 20a.--Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) and Perceptions of PTC.

Elapsed Time	Tasteless						Sour						Sweet						Bitter						Salty					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. 0.1-0.9 hrs. (n=263)	113	43.0	93	35.4	83	31.6	5	1.9	11	4.2	17	6.5	0	0	3	1.1	0	0	140	53.2	152	57.8	161	61.2	5	1.9	4	1.5	2	0.8
2. 1.0-1.9 hrs. (n=364)	152	40.6	118	31.6	85	22.7	18	4.8	11	2.9	21	5.6	0	0	1	0.3	0	0	202	54.0	242	64.7	265	70.9	2	0.5	2	0.5	3	0.8
3. 2.0-2.9 hrs. (n=262)	89	34.0	74	28.2	56	21.4	10	3.8	11	4.2	11	4.2	0	0	0	0	0	0	161	61.5	175	66.8	194	74.0	2	0.8	2	0.8	1	0.4
4. 3.0-3.9 hrs. (n=151)	59	39.1	49	32.5	35	23.2	6	4.0	4	2.6	6	4.0	1	0.7	0	0	1	0.7	84	55.6	97	64.2	109	72.2	1	0.7	1	0.7	0	0
5. 4.0-4.9 hrs. (n=60)	19	31.7	14	23.3	13	21.7	4	6.7	2	3.3	3	5.0	0	0	0	0	0	0	36	60.0	44	73.3	44	73.3	1	1.7	0	0	0	0
6. 5.0-9.9 hrs. (n=88)	28	31.8	25	28.4	20	22.7	6	6.8	4	4.5	4	4.5	0	0	0	0	0	0	53	60.2	58	65.9	62	70.5	1	1.1	1	1.1	2	2.3
7. 10.0+ hrs. (n=227)	101	44.5	75	33.0	54	23.8	5	2.2	9	4.0	7	3.1	1	0.4	1	0.4	0	0	120	52.9	142	62.6	164	72.2	0	0	0	0	2	0.9
Totals	561	39.4	448	31.4	346	24.3	54	3.8	52	3.6	69	4.8	2	0.1	5	0.4	1	0.09	796	55.9	910	63.9	999	70.1	12	0.8	10	0.7	10	0.7

PTC Low (20.31 mg/l): Cramer's V = 0.07296; Lambda (Asymmetric) = 0.00381 with Elapsed Time dependent; Lambda (Symmetric) = 0.01257 with PTC Low dependent.

PTC Med (40.63 mg/l): Cramer's V = 0.05936; Lambda (Asymmetric) = 0.00381 with Elapsed Time dependent; Lambda (Symmetric) = 0 with PTC Med dependent.

PTC High (81.25 mg/l): Cramer's V = 0.07092; Lambda (Asymmetric) = 0.00095 with Elapsed Time dependent; Lambda (Symmetric) = 0 with PTC High dependent.

Table 20b.--Comparison of Elapsed Time (Time of Last Food Eaten by Respondent) and PTC Taster-Nontaster and Bitter-Nonbitter Status.

Elapsed Time (hours)	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. 0.1-0.9 hrs. (n=263)	150	57.0	170	64.6	180	68.4	113	43.0	93	35.4	83	31.6	140	53.2	152	57.8	161	61.2	123	46.8	111	42.2	102	38.8
2. 1.0-1.9 hrs. (n=374)	222	59.4	256	68.4	289	77.3	152	40.6	118	31.6	85	22.7	202	54.0	242	64.7	265	70.9	172	46.0	132	35.3	109	29.1
3. 2.0-2.9 hrs. (n=262)	173	66.0	188	71.8	206	78.2	89	34.0	74	28.2	56	21.4	161	61.5	175	66.8	194	74.0	101	38.5	87	33.2	68	26.0
4. 3.0-3.9 hrs. (n=151)	92	60.9	102	67.5	116	76.8	59	39.1	49	32.5	35	23.2	84	55.6	97	64.2	109	72.2	67	44.4	54	35.8	42	27.8
5. 4.0-4.9 hrs. (n=60)	41	68.3	46	76.7	47	78.3	19	31.7	14	23.3	13	21.7	36	60.0	44	73.3	44	73.3	24	40.0	16	26.7	16	26.7
6. 5.0-9.9 hrs. (n=88)	60	68.2	63	71.6	68	77.3	28	31.8	25	28.4	20	22.7	53	60.2	58	65.9	62	70.5	35	39.8	30	34.1	26	29.5
7. 10.0+ hrs. (n=227)	126	55.5	152	67.0	173	76.2	101	44.5	75	33.0	54	23.8	120	52.9	142	62.6	164	72.2	107	47.1	85	37.4	63	27.8
Totals	864	60.6	977	68.6	1079	75.7	561	39.4	448	31.4	346	24.3	796	55.9	910	63.9	999	70.1	629	44.1	515	36.1	426	29.9

PTC Low (20.31 mg/l): $\chi^2_6 = 10.97$, $p > 0.05$.

PTC Med (40.63 mg/l): $\chi^2_6 = 5.67$, $p > 0.05$.

PTC High (81.25 mg/l): $\chi^2_6 = 9.16$, $p > 0.05$.

PTC Low: $\chi^2_6 = 6.51$, $p > 0.05$.

PTC Med: $\chi^2_6 = 7.96$, $p > 0.05$.

PTC High: $\chi^2_6 = 13.05$, $p < 0.05$.

tasters, and nontasters were not significant by Chi-square analyses for any of the PTC concentrations. Furthermore, no significant differences were found for bitter-nonbitter responses when the low and medium PTC concentrations were analyzed. Bitter-nonbitter responses for the high concentration of PTC however were found to be significant at the 5 percent level.

During these analyses, it was noted, the deviations for the 0.1-0.9 hour elapsed time group made the greatest contributions to the Chi-square value obtained. Subsequent analyses were carried out to compare the frequencies of tasters and nontasters as well as those for the bitter and nonbitter responders for this first elapsed time group with the other six time groupings. These results are presented in Table 20c. As can be seen the relationships of the elapsed time and taster-nontaster status for less than one hour versus greater than one hour is significant for the high concentration of PTC. The bitter-nonbitter perceptions with these time divisions are significant for both the medium and high concentrations of PTC.

Antidesma Perceptions and PTC Responses

To facilitate comparisons with the previous report which led to the initiation of this study, taste perceptions of both Antidesma solutions were compared to taste responses for the three concentrations of PTC. Comparisons of perceptions of Antidesma I and II with responses to the low concentration of PTC are reported in Table 21a. Inspection of the frequencies of each specific Antidesma perception with those of specific PTC responses (column percentages) reveals no

Table 20c.--Comparison of PTC Taster-Nontaster and Bitter-Nonbitter Status with Elapsed Time: Less than One Hour Versus Greater than One Hour.

Elapsed Time	Tasters						Nontasters						Bitter						Nonbitter					
	PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High		PTC Low		PTC Med		PTC High	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
> 1 hour (n=263)	150	57.0	170	64.6	180	68.4	113	43.0	93	35.4	83	31.6	140	53.2	152	57.8	161	61.2	123	46.8	111	42.2	102	38.8
≤ 1 hour (n=1162)	714	61.4	807	69.4	899	77.4	448	38.6	355	30.6	263	22.6	656	56.5	758	65.2	838	72.1	506	43.5	404	34.8	324	27.9
Totals	864	60.6	977	68.6	1079	75.7	561	39.4	448	31.4	346	24.3	796	55.9	910	63.9	999	70.1	629	44.1	515	36.1	426	29.9

PTC Low (20.31 mg/l): $\chi_1^2 = 1.94$, $p > 0.05$.

PTC Med (40.63 mg/l): $\chi_1^2 = 2.30$, $p > 0.05$.

PTC High (81.25 mg/l): $\chi_1^2 = 9.29$, $p < 0.05$.

PTC Low: $\chi_1^2 = 0.90$, $p > 0.05$.

PTC Med: $\chi_1^2 = 5.14$, $p < 0.05$.

PTC High: $\chi_1^2 = 12.16$, $p < 0.05$.

Table 21a.--Comparisons of Taste Responses of Low Concentration of PTC and Perceptions of Antidesma.

PTC Low (20.31 mg/l)	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless (n=563)	6	1.1	0	0	191	33.9	245	43.5	296	52.6	134	23.8	66	11.7	180	32.0	4	0.7	4	0.7
Sour (n=55)	0	0	0	0	22	40.0	17	30.9	24	43.6	16	29.1	9	16.4	22	40.0	0	0	0	0
Sweet (n=2)	0	0	0	0	2	100.0	1	50.0	0	0	1	50.0	0	0	0	0	0	0	0	0
Bitter (n=806)	6	0.7	0	0	297	36.8	390	48.4	407	50.5	211	26.2	91	11.3	201	24.9	5	0.6	4	0.5
Salty (n=12)	0	0	0	0	5	41.7	7	58.3	5	41.7	3	25.0	2	16.7	2	16.7	0	0	0	0
Total	12	0.8	0	0	517	36.0	600	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.6	8	0.6

Antidesma I (Ad I):
Cramer's V = 0.03896
Lambda (Asymmetric) = 0.00283 with Antidesma I dependent = 0 with PTC Low dependent
Lambda (Symmetric) = 0.00370

Antidesma II (Ad II):
Cramer's V = 0.06247
Lambda (Asymmetric) = 0.00643 with Antidesma II dependent = 0 with PTC Low dependent
Lambda (Symmetric) = 0.00355

significant associations of overall Antidesma responses and this concentration of PTC as verified by Cramer's V and Lambda values.

Further comparisons of Antidesma responses with the PTC low concentration are reported in Table 21b. It can be observed that for Antidesma I, no significant differences are seen for these responses when compared to PTC taster and nontasters as well as PTC bitter and nonbitter responders. Similar lack of significant relationship of Antidesma II responses is seen when compared to the PTC taster-nontaster classification. However, Antidesma II perceptions when compared to the PTC bitter-nonbitter status were found to be significant ($p < 0.05$).

Table 21c presents a different treatment of the above data in which Antidesma perceptions are divided into bitter and nonbitter classes and these again compared with PTC taster-nontaster and bitter-nonbitter classifications. As can be seen the Antidesma I groups are not significant for either of these comparisons while Antidesma II bitter-nonbitter perceptions are significant at the 5 percent level when compared with both classifications.

The same types of analyses as reported for Antidesma and the low PTC concentration were performed for the medium and high concentrations of PTC. In Table 22a, it can be seen that for overall Antidesma I and II taste perceptions, the frequencies of PTC responses for the medium concentration are apparently randomly distributed as evidenced by the Cramer's V and Lambda values, hence any differences observed were not statistically significant. When responses to the medium concentration of PTC were separated into the taster-nontaster and bitter-nonbitter divisions (Table 22b) and compared to each Antidesma perception, a

Table 21b.--Comparison of Antidesma I and II Responses with PTC Low Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma I								
Tasteless (n=12)	6	50.0	6	50.0	6	50.0	6	50.0
Sour (n=517)	326	63.1	191	36.9	297	57.4	220	42.6
Sweet (n=732)	436	59.6	296	40.4	407	55.6	325	44.4
Bitter (n=168)	102	60.7	66	39.3	91	54.2	77	45.8
Salty (n=9)	5	55.6	4	44.4	5	55.6	4	44.4
Totals	875	60.8	563	39.2	806	56.1	632	43.9
	$\chi^2_4 = 0.001$, $p > 0.05$				$\chi^2_4 = 0.274$, $p > 0.05$			

Table 21b.--Continued.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma II								
Sour (n=660)	415	62.9	245	37.1	390	59.1	270	40.9
Sweet (n=365)	231	63.3	134	36.7	211	57.8	154	42.2
Bitter (n=405)	225	55.6	180	44.4	201	49.6	204	50.4
Salty (n=8)	4	50.0	4	50.0	4	50.0	4	50.0
Totals	875	60.8	563	39.2	806	56.1	632	43.9
	$\chi^2_3 = 7.269$, $p > 0.05$				$\chi^2_3 = 9.843$, $p < 0.05$			

Table 21c.--Comparison of Antidesma Bitter-Nonbitter Responses with PTC Low Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Taster		PTC Nontaster		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma I								
Bitter	102	60.7	66	39.3	91	54.2	77	45.8
Nonbitter	773	60.9	497	39.2	715	56.3	555	43.7
Totals	875	60.8	563	39.2	806	56.1	632	43.9
	$\chi_1^2 = 0.001$, $p > 0.05$				$\chi_1^2 = 0.274$, $p > 0.05$			
Antidesma II								
Bitter	225	55.6	180	44.4	201	49.6	204	50.4
Nonbitter	650	62.9	383	37.1	605	58.6	428	41.4
Totals	875	60.8	563	39.2	806	56.1	632	43.9
	$\chi_1^2 = 6.632$, $p < 0.05$				$\chi_1^2 = 9.435$, $p < 0.05$			

Table 22a.--Comparison of Taste Responses of Medium Concentration of PTC with Perceptions of Antidesma.

PTC Medium (40.63mg/l)	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless (n=450)	4	0.9	0	0	151	33.6	192	42.7	238	52.9	115	25.6	55	12.2	140	31.1	2	0.4	3	0.7
Sour (n=53)	1	1.9	0	0	17	32.1	18	34.0	26	49.1	9	17.0	9	17.0	25	47.2	0	0	1	1.9
Sweet (n=5)	0	0	0	0	2	40.0	3	60.0	2	40.0	0	0	1	20.0	2	40.0	0	0	0	0
Bitter (n=920)	7	0.8	0	0	343	37.3	443	48.2	461	50.1	240	26.1	102	11.1	233	25.3	7	0.8	4	0.4
Salty (n=10)	0	0	0	0	4	40.0	4	40.0	5	50.0	1	10.0	1	10.0	5	50.0	0	0	0	0
Totals	12	0.8	0	0	517	36.0	660	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.6	8	0.6

Antidesma I: Cramer's V = 0.03202, Lambda (Asymmetric) = 0 with Ad I dependent = 0 with PTC Medium dependent; Lambda (Symmetric) = 0.

Antidesma II: Cramer's V = 0.07256, Lambda (Asymmetric) = 0.01028 with Ad II dependent = 0 with PTC medium dependent; Lambda (Symmetric) = 0.00617.

Table 22b.--Comparison of Antidesma I and II Responses with PTC Medium Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma I								
Tasteless (n=12)	8	66.7	4	33.3	7	58.3	5	41.7
Sour (n=517)	366	70.8	151	29.2	343	66.3	174	33.7
Sweet (n=732)	494	67.5	238	32.5	461	63.0	271	37.0
Bitter (n=168)	113	67.3	55	32.7	102	60.7	66	39.3
Salty (n=9)	7	77.8	2	22.2	7	77.8	2	22.2
Totals	988	68.7	450	31.3	920	64.0	518	36.0
	$\chi^2_4 = 2.084$, $p > 0.05$				$\chi^2_4 = 3.258$, $p > 0.05$			

Table 22b.--Continued.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma II								
Sour (n=660)	468	70.9	192	29.1	443	67.1	217	32.9
Sweet (n=365)	250	68.5	115	31.5	240	65.8	125	34.2
Bitter (n=405)	265	65.4	140	34.6	233	57.5	172	42.5
Salty (n=8)	5	62.5	3	37.5	4	50.0	4	50.0
Totals	988	68.7	450	31.3	920	64.0	518	36.0
	$\chi^2_3 = 3.659$, $p > 0.05$				$\chi^2_3 = 11.309$, $p < 0.05$			

significant difference was found for overall Antidesma II perceptions with respect to the PTC bitter-nonbitter dichotomy. Similar results were obtained when these same PTC classes were compared to bitter-nonbitter groupings of Antidesma as in Table 22c. As shown, statistical significance was observed only when Antidesma II bitter-nonbitter perceptions are contrasted with bitter-nonbitter responses to this medium PTC concentration.

For the high concentration of PTC, similar trends as reported for the previous two concentrations are evident, in that overall perceptions of the Antidesma solutions are not significantly associated with PTC responses (see Table 23a). Application of the PTC taster-nontaster and bitter-nonbitter classifications with individual perceptions to Antidesma I and II (Table 23b) results in significance only for the PTC bitter-nonbitter category in Antidesma II. Furthermore, as with the previous PTC concentrations, comparisons of bitter-nonbitter perceptions of Antidesma solutions with the high PTC concentration (Table 23c), one finds significant differences only with respect to PTC bitter-nonbitter responses for Antidesma II. It should be noted that in all of the above instances where significant differences were found, such differences were primarily due to the less than expected frequencies of subjects who responded bitter to Antidesma as well as bitter to PTC.

Comparisons of Taste Perceptions of Antidesma I and Antidesma II

Perceptions of the two Antidesma solutions are compared in Table 24a. As is apparent, the major combinations of responses were sour responses to both which were recorded by 324 subjects (22.5

Table 22c.--Comparison of Antidesma Bitter-Nonbitter Responses with PTC Medium Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Taster		PTC Nontaster		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma I								
Bitter (n=168)	113	67.3	55	32.7	102	60.7	66	39.3
Nonbitter (n=1270)	875	68.9	395	31.1	818	64.4	452	35.6
Totals	988	68.7	450	31.3	920	64.0	518	36.0
	$\chi_1^2 = 0.185$, $p > 0.05$				$\chi_1^2 = 0.001$, $p > 0.05$			
Antidesma II								
Bitter (n=405)	265	65.4	140	34.6	233	57.5	172	42.5
Nonbitter (n=1033)	723	70.0	310	30.0	687	66.5	346	33.5
Totals	988	68.7	450	31.3	920	64.0	518	36.0
	$\chi_1^2 = 2.812$, $p > 0.05$				$\chi_1^2 = 10.169$, $p < 0.05$			

Table 23a.--Comparison of Taste Responses of High Concentration of PTC with Perceptions of Antidesma.

PTC High (81.25 mg/l)	Tasteless				Sour				Sweet				Bitter				Salty			
	Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad II		Ad I		Ad I	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless (n=348)	1	0.3	0	0	108	31.0	141	40.5	192	55.2	93	26.7	46	13.2	112	32.2	1	0.3	2	0.6
Sour (n=71)	5	5.7	0	0	23	32.4	31	43.7	31	43.7	10	14.1	14	14.1	30	42.3	2	2.8	0	0
Sweet (n=1)	0	0	0	0	1	100.0	0	0	0	0	1	100.0	0	0	0	0	0	0	0	0
Bitter (n=1008)	6	0.6	0	0	383	38.0	485	48.1	502	49.8	259	25.7	111	11.0	258	25.6	6	0.6	6	0.6
Salty (n=10)	0	0	0	0	2	20.0	3	30.0	7	70.0	2	20.0	1	10.0	5	50.0	0	0	0	0
Totals	12	0.8	0	0	517	36.0	660	45.9	732	50.9	365	25.4	168	11.7	405	28.2	9	0.6	8	0.6

Antidesma I (Ad I): Cramer's V = 0.09473, Lambda (Asymmetric) = 0.00142 with Ad I dependent
= 0 with PTC high dependent
Lambda (Symmetric) = 0.00088

Antidesma II (Ad II): Cramer's V = 0.07198; Lambda (Asymmetric) = 0.00386 with Ad II dependent,
= 0 with PTC high dependent
Lambda (Symmetric) = 0.00248

Table 23b.--Comparison of Antidesma I and II Responses with PTC High Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.		No.	%	No.	%
Antidesma I								
Tasteless (n=12)	11	91.67	1	8.3	6	50.0	6	50.0
Sour (n=517)	409	79.1	108	20.9	383	74.1	134	25.9
Sweet (n=732)	540	73.8	192	26.2	502	68.6	230	31.4
Bitter (n=168)	122	72.6	46	27.4	111	66.1	57	33.9
Salty (n=9)	8	88.9	1	11.1	6	66.7	3	33.3
Totals	1090	75.8	348	24.2	1008	70.1	430	29.9
	$\chi^2_4 = 8.151$, $p > 0.05$				$\chi^2_4 = 8.84$, $p > 0.05$			

Table 23b.--Continued.

	PTC Tasters		PTC Nontasters		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma II								
Sour (n=660)	519	78.6	141	21.4	485	73.5	175	26.5
Sweet (n=365)	272	74.5	93	25.5	259	71.0	106	29.0
Bitter (n=405)	293	72.3	112	27.7	258	63.7	147	36.3
Salty (n=8)	6	75.0	2	25.0	6	75.0	2	25.0
Totals	1090	75.8	348	24.2	1008	70.1	430	29.9
	$\chi^2_3 = 5.859$, $p > 0.05$				$\chi^2_3 = 11.734$, $p < 0.05$			

Table 23c.--Comparison of Antidesma Bitter-Nonbitter Responses with PTC High Taster-Nontaster and Bitter-Nonbitter Status.

	PTC Taster		PTC Nontaster		PTC Bitter		PTC Nonbitter	
	No.	%	No.	%	No.	%	No.	%
Antidesma I								
Bitter (n=168)	122	72.6	46	27.4	111	66.1	57	33.9
Nonbitter (n=1270)	968	76.2	302	23.8	897	70.6	373	29.4
Totals	1090	75.8	348	24.2	1008	70.1	430	29.9
	$\chi_1^2 = 1.049$, $p > 0.05$				$\chi_1^2 = 1.474$, $p > 0.05$			
Antidesma II								
Bitter (n=405)	293	72.3	112	27.7	258	63.7	147	36.3
Nonbitter (n=1033)	797	77.2	236	22.8	750	72.6	283	27.4
Totals	1090	75.8	348	24.2	1008	70.1	430	29.9
	$\chi_1^2 = 3.667$, $p > 0.05$				$\chi_1^2 = 10.997$, $p < 0.05$			

Table 24a.--Comparison of Taste Perceptions of Antidesma I and Antidesma II.

Count Row Pct Col Pct Tot Pct	Antidesma II Perceptions				Row Total
	Sour	Sweet	Bitter	Salty	
Antidesma I Perceptions					
Tasteless	6 50.0 .9 .4	2 16.7 .5 .1	4 33.3 1.0 .3	0 0 0 0	12 .8
Sour	324 62.7 49.1 22.5	63 12.2 17.3 4.4	126 24.4 31.1 8.8	4 .8 50.0 .3	517 36.0
Sweet	270 36.9 40.9 18.8	277 37.8 75.9 19.3	183 25.0 45.2 12.7	2 .3 25.0 .1	732 50.9
Bitter	58 34.5 8.8 4.0	20 11.9 5.5 1.4	89 53.0 22.0 6.2	1 .6 12.5 .1	168 11.7

Table 24a.--Continued.

Count Row Pct Col Pct Tot Pct	Antidesma II Perceptions				Row Total
	Sour	Sweet	Bitter	Salty	
Antidesma I Perceptions					
Salty	2 22.2 .3 .1	3 33.3 .8 .2	3 33.3 .7 .2	1 11.1 12.5 .1	9 .6
Column Total %	660 45.9	385 25.4	405 28.2	8 .6	1438 100.0

Cramer's V = 0.21805

Lambda (Asymmetric) = 0.07932 with Antidesma I dependent
= 0.05013 with Antidesma II dependent

Lambda (Symmetric) = 0.06402

percent of total sample). The second most frequent response combination was sweet perceptions to both (19.3 percent) followed by sweet Ad I--sour Ad II (18.8 percent), sweet Ad I-bitter Ad II (12.7 percent), sour Ad I-bitter Ad II (8.8 percent) and bitter for both solutions (6.2 percent). Other combinations were reported with frequencies of less than 4.5 percent. While these responses to Antidesma I and Antidesma II are not perfectly correlated, Cramer's V and Lambda values are much larger than those previously encountered in the PTC comparisons thus suggesting a stronger association between the overall perceptions of these two solutions than for PTC. This association is further substantiated by data presented in Table 24b. Comparisons of the major perceptions of Antidesma I (sour, sweet and bitter) with the dichotomous frequencies of Antidesma II taste perceptions shows that in each case, these values are much greater than other frequencies obtained in that specific column. For example, the frequency of bitter perceptions for both Antidesma solutions is 53.0 percent as compared to frequencies of 25-33.3 percent for other Antidesma I-Antidesma II bitter combinations. As verified by Chi-square values, each of the differences for comparisons made in Table 24b are highly significant. Although not presented but as expected from these data, similar significant differences are obtained when each Antidesma II perception is compared with dichotomized Antidesma I perceptions (bitter-nonbitter, etc.). Furthermore, as seen in Table 24c, when dichotomous categories of the major perceptions for both solutions are compared, differences are again highly significant.

Table 24b.--Comparison of Taste Perceptions of Antidesma Solutions: Overall Antidesma Perceptions with Antidesma II (Bitter-Nonbitter, Sour-Nonsour, Sweet-Nonsweet) Perceptions.

Antidesma I Perceptions	No.	Antidesma II Perceptions											
		Bitter		Nonbitter		Sour		Nonsour		Sweet		Nonsweet	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless	12	4	33.3	8	66.7	6	50.0	6	50.0	2	16.7	10	83.3
Sour	517	126	22.4	391	75.6	324	62.7	193	37.3	63	12.2	454	87.8
Sweet	732	183	25.0	549	75.0	270	36.9	462	63.1	277	37.8	455	62.2
Bitter	168	89	53.0	79	47.0	58	34.5	110	65.5	20	11.9	148	88.1
Salty	9	3	33.3	6	66.7	2	22.2	7	77.8	3	33.3	6	66.7
Totals	1438	405	28.2	1032	71.8	660	45.9	778	54.1	365	25.4	1073	74.7

Antidesma I with Antidesma II Bitter-Nonbitter Perceptions: $\chi^2_4 = 58.72$, $p < 0.05$

Antidesma I with Antidesma II Sour-Nonsour Perceptions: $\chi^2_4 = 93.37$, $p < 0.05$

Antidesma I with Antidesma II Sweet-Nonsweet Perceptions: $\chi^2_4 = 124.44$, $p < 0.05$

Table 24c.--Comparison of Antidesma I (Bitter-Nonbitter, Sour-Nonsour, Sweet-Nonsweet) Perceptions with Antidesma II (Bitter-Nonbitter, Sour-Nonsour, Sweet-Nonsweet) Perceptions.

Antidesma I	Total No.	Antidesma II				
		Bitter		Nonbitter		
		No.	%	No.	%	
Bitter	168	89	53.0	79	47.0	
Nonbitter	1270	316	24.9	954	75.1	$\chi^2_1 = 57.9$, $p < 0.05$
Total	1438	405	28.2	1033	71.8	
		Sour		Nonsour		
		No.	%	No.	%	
Sour	517	324	62.7	193	37.3	
Nonsour	921	336	36.5	585	63.5	$\chi^2_1 = 91.44$, $p < 0.05$
Total	1438	660	45.9	778	54.1	

Table 24c.--Continued.

Antidesma I	Total No.	Antidesma II				
		Sweet		Nonsweet		
		No.	%	No.	%	
Sweet	732	277	37.8	455	62.2	
Nonsweet	706	88	12.5	618	87.5	$\chi^2_1 = 122.19$, $p < 0.05$
Total	1438	365	25.4	1073	74.7	

Taste Perception Family Studies

To determine if Antidesma taste perceptions are consistent with a simple dominant-recessive genetic hypothesis, data were obtained from 115 families. As reported previously, these family studies included taste perceptions as well as general demographic information for 112 two generation and 3 three generation families. In the analyses which follow, two generation families will be considered separately from those of three generation families.

Two Generation Families--General Demographic Data

The 112 two generation family data included information from 443 subjects: 224 parents and 219 children for an average sibship of 1.955 children per family. Within the offspring group there were 119 (54.3 percent) males and 100 (45.7 percent) females. With respect to race 88 (78.6 percent) families were White/Caucasian and 24 (21.4 percent) were nonwhite matings. In this latter category there were 21 Black/Afro American, one Chicano and two families in which one parent was white while the other parent was of Chicano or Spanish American heritage. Paternal ages ranged from 27 to 64 years (mean = 43.54) and maternal ages ranged from 28 to 62 years (mean = 41.30). The overall parental mean age was 42.43 years. Age ranges for male and female offspring were 7-23 years and 7-45 years respectively with average male and female progeny ages of 13.86 and 13.31 years (Note: As previously indicated, offspring younger than age seven were not included in the sampling).

As reported for the total sample, frequency data on smoking status and elapsed time since last food eaten were also obtained for families. Within the parental group, 62 (27.7 percent) were smokers

and 162 (72.3 percent) were nonsmokers. Among the offspring, there were 11 (5.0 percent) smokers and 208 (95.0 percent) nonsmokers. The time of last food eaten by parents ranged from 0.1 to 15.3 hours with an average elapsed time of 2.25 hours since last food ingested. For offspring, this elapsed time range was 0.1-10.8 hours with a mean of 1.82 hours.

Taste Perceptions of Families

Data tabulated in Table 25a compares taste responses of parents and offspring for the control solutions. As can be seen, these data show that similar to previously reported results for the overall sample, parents and offspring more often misperceived the sour and bitter controls. Furthermore, the misclassification (error) rates for offspring were slightly greater than those of the parental group for each of the controls except salty. Offspring also recorded higher average intensities for the control solutions. From the comparison of misclassifications of these solutions by parents and offspring as reported in Table 25b, it will be noted that perceptual errors were not significantly different for the two groups ($p > 0.05$).

Overall taste perceptions of Antidesma are recorded for parents and offspring in Table 26a. Parents most often perceived Antidesma I as sour (50.9 percent) or sweet (30.4 percent). Conversely offspring perception frequencies were greater for sweet (43.8 percent) followed by sour (37.0 percent). Bitter perceptions of this solution were similar for the two groups (17.4 percent and 17.8 percent) while only individuals in the parental group judged this solution as tasteless and only offspring reported salty perceptions. These differences in perceptions

Table 25a.--Comparison of Parental and Offspring Perceptions of Controls.

Control Solutions	Parents					Offspring				
	"Correct"		"Incorrect"		Mean Intensity	"Correct"		"Incorrect"		Mean Intensity
	No.	%	No.	%		No.	%	No.	%	
Tasteless	224	100.0	0	0	0.000	217	99.1	2	0.9	0.068
Sour	205	91.5	19	8.5	3.996	195	89.0	24	11.0	4.027
Sweet	223	99.6	1	0.4	2.826	218	99.5	1	0.5	3.005
Bitter	217	96.9	7	3.1	3.817	209	95.4	8	4.6	4.087
Salty	219	97.8	5	2.2	3.540	216	98.6	3	1.4	3.813

Table 25b.--Comparison of Misclassification (Errors) of Controls for Parents and Offspring.

Errors	Frequencies of Misclassification (Errors) of Controls (Tasteless, Salty, Bitter, Sweet and Sour)			
	Parents		Offspring	
	No.	%	No.	%
0	198	88.4	186	84.9
1	21	9.4	28	12.8
$\geq$ 2	5	2.2	5	2.3
Total	224	100.0	219	100.0

$\chi^2_2 = 1.318, \quad p > 0.05$

of Antidesma I by parents and offspring were significant at the 5 percent level. For Antidesma II parents and offspring most often perceived this solution as sour, followed by bitter and sweet with two individuals in both groups recording salty perceptions. Differences between the groups were not significant ($p > 0.05$). Furthermore, when bitter versus nonbitter Antidesma responses of parents and offspring are compared (Table 26b), no significant differences between the two groups were found for these taste perceptions.

Table 27a compares the taste responses of the three concentrations of PTC for parents and offspring. Overall taste perceptions frequencies for these groups were similar for each concentration with most subjects judging these solutions as bitter or tasteless. As shown, Chi-square analyses revealed the lack of significant differences between the two groups for all of the PTC concentrations. Similarly, no

Table 26a.--Comparison of Taste Perceptions of Antidesma for Parents and Offspring.

	Antidesma I				Antidesma II			
	Parents		Offspring		Parents		Offspring	
	No.	%	No.	%	No.	%	No.	%
Tasteless	3	1.3	0	0	0	0	0	0
Sour	114	50.9	81	37.0	138	61.2	108	49.3
Sweet	68	30.4	96	43.8	31	14.3	43	19.6
Bitter	39	17.4	39	17.8	53	23.7	66	30.1
Salty	0	0	3	1.4	2	0.9	2	0.9
Totals	224	100.0	219	100.0	224	100.0	219	100.0
	$\chi^2_4 = 16.273$, $p < 0.05$				$\chi^2_3 = 6.411$, $p > 0.05$			

Table 26b.--Comparison of Antidesma Bitter-Nonbitter Responses for Parents and Offspring.

	Antidesma I				Antidesma II			
	Parents		Offspring		Parents		Offspring	
	No.	%	No.	%	No.	%	No.	%
Bitter	39	17.4	39	17.8	53	23.7	66	30.1
Nonbitter	185	82.6	180	82.2	171	76.3	153	69.9
Totals	224	100.0	219	100.0	224	100.0	219	100.0
	$\chi_1^2 = 0.011$, $p > 0.05$				$\chi_1^2 = 2.366$, $p > 0.05$			

Table 27a.--Comparison of Taste Perceptions of PTC for Parents and Offspring.

	PTC Low				PTC Med				PTC High			
	Parents		Offspring		Parents		Offspring		Parents		Offspring	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasteless	81	36.2	76	34.7	66	29.5	66	30.1	55	24.6	54	24.6
Sour	6	2.7	18	8.2	8	3.6	12	5.5	9	4.0	16	7.3
Sweet	0	0	0	0	0	0	1	0.5	0	0	0	0
Bitter	135	60.3	121	55.3	150	67.0	134	61.2	158	70.5	143	65.8
Salty	2	0.9	4	1.8	0	0	6	2.7	2	0.9	5	2.3
Totals	224	100.0	219	100.0	224	100.0	219	100.0	224	100.0	219	100.0
	$\chi^2_3 = 7.529$, $p > 0.05$				$\chi^2_4 = 8.646$, $p > 0.05$				$\chi^2_3 = 3.849$, $p > 0.05$			

significant differences were seen when parents and progeny were compared with respect to PTC taster-nontaster and bitter-nonbitter responses (Table 27b).

Genetic Analyses of Antidesma and PTC Taste Perceptions

From the taste perceptions for Antidesma and PTC recorded by individuals in families, 115 pedigrees were constructed (Fig. 5). As indicated, the top half of the pedigree symbols shows the individual perception of Antidesma I while the bottom half shows the perception of Antidesma II. Presumptive PTC genotypes are recorded below each symbol based on the responses recorded for the PTC concentration of 81.25 mg/l and the general assumption that nontasting represents homozygosity for the recessive allele while the ability to taste PTC is determined by the presence of the dominant allele.

Genetic Analysis of Family PTC Data (Two Generation Families)

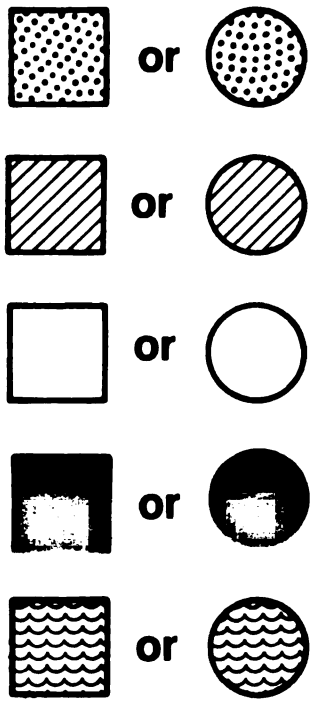
A summary of family PTC perceptions for the 112 two generation families with respect to types of matings and the resultant offspring are recorded in Table 28. When the numbers of offspring from the various mating types were tested for randomness (chance) by Chi-square, it was found that the differences between observed and expected frequencies were highly significant ($X^2 = 80.89$, $p < 0.05$). The data were then analyzed to determine if they conformed to the well established hypothesis that PTC tasting is dominant and nontasting is recessive. Following the estimate of q^2 and q based on the total frequency of nontasters in the population sampled, Snyder's ratios were applied to calculate the proportions of nontaster offspring expected from various mating

Table 27b.--Comparison of Taster-Nontaster and Bitter-Nonbitter Perceptions of PTC for Parents and Offspring.

	PTC Low				PTC Med				PTC High			
	Parents		Offspring		Parents		Offspring		Parents		Offspring	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tasters	143	63.8	143	65.3	158	70.5	153	69.9	169	75.4	165	75.4
Nontasters	81	36.2	76	34.7	66	29.5	66	30.1	55	24.6	54	24.6
Totals	224	100.0	219	100.0	224	100.0	219	100.0	224	100.0	219	100.0
	$\chi_1^2 = 0.102$, $p > 0.05$				$\chi_1^2 = 0.024$, $p > 0.05$				$\chi_1^2 = 0.001$, $p > 0.05$			
Bitter	135	60.3	121	55.3	150	67.0	134	61.2	158	70.5	144	65.3
Nonbitter	89	39.7	98	44.7	74	33.0	85	38.8	66	29.5	75	34.7
Totals	224	100.0	219	100.0	224	100.0	219	100.0	224	100.0	219	100.0
	$\chi_1^2 = 1.142$, $p > 0.05$				$\chi_1^2 = 1.605$, $p > 0.05$				$\chi_1^2 = 1.167$, $p > 0.05$			

Fig. 5.-- **Genetic Studies of Taste Perceptions of Antidesma and Phenylthiocarbamide**

Family Pedigrees



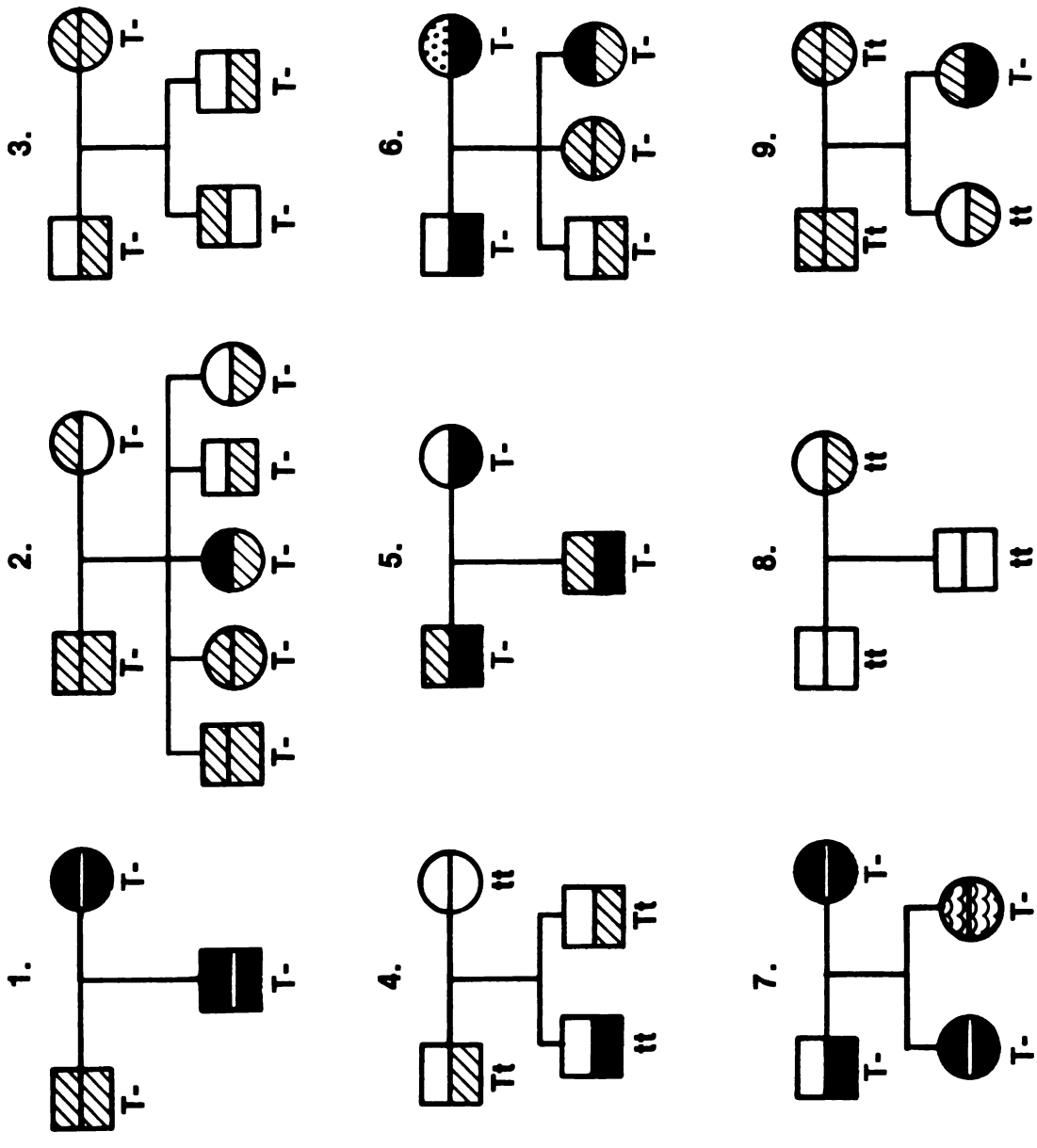
Legend:

Top : Taste Perceptions of Antidesma I

Bottom: Taste Perceptions of Antidesma II

Letters below = Presumptive PTC Genotypes:

T = Taster allele
t = Nontaster allele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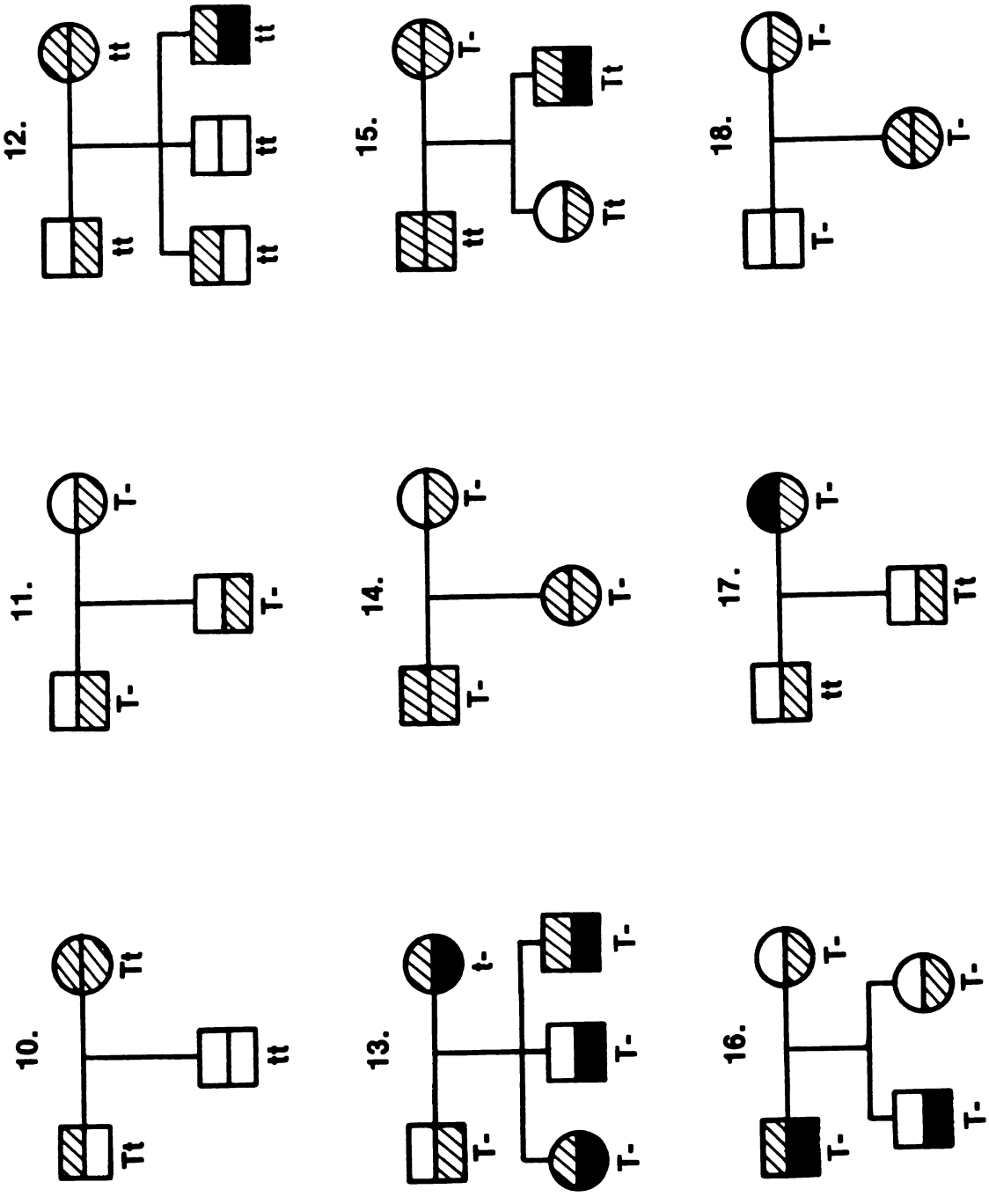
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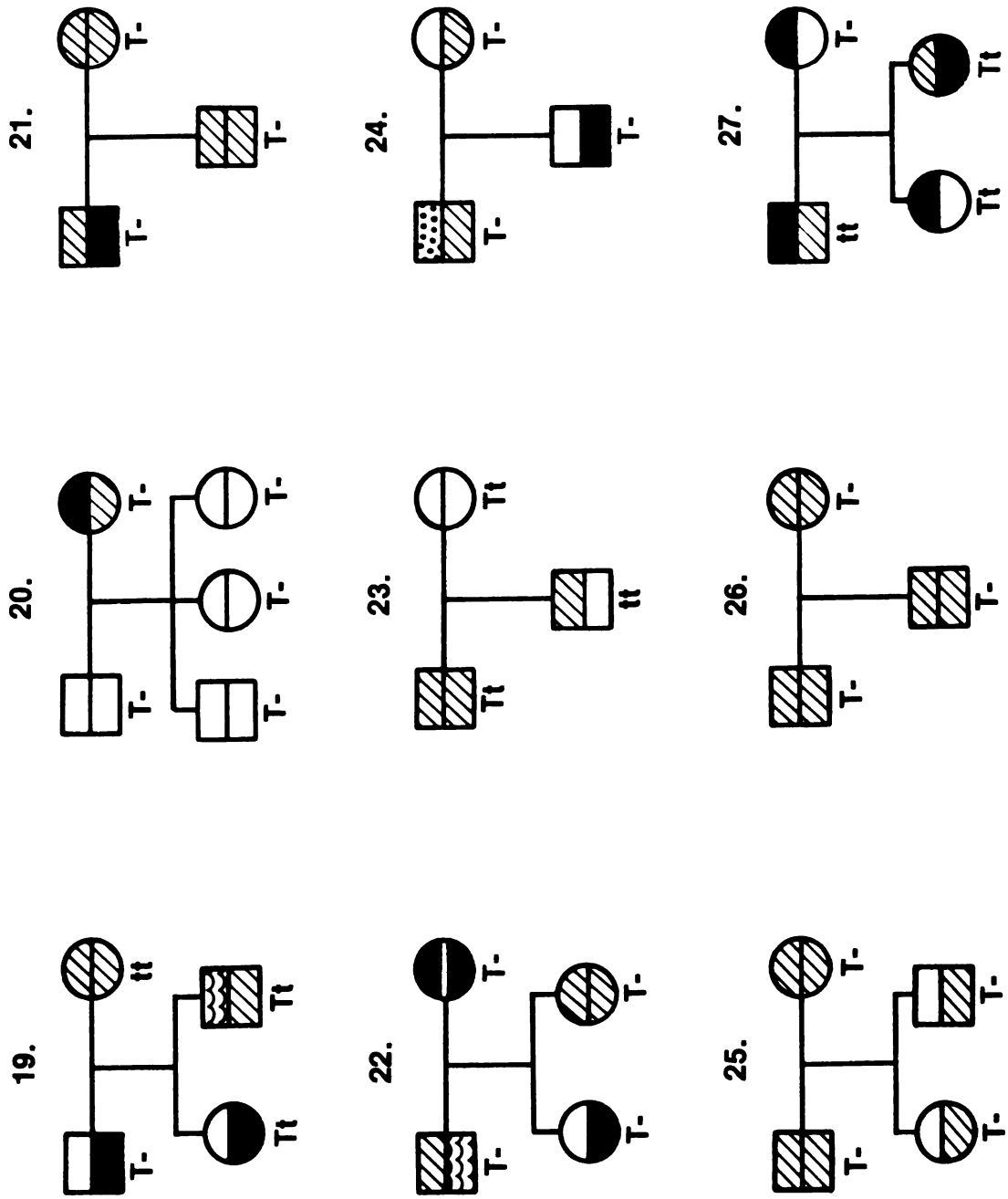
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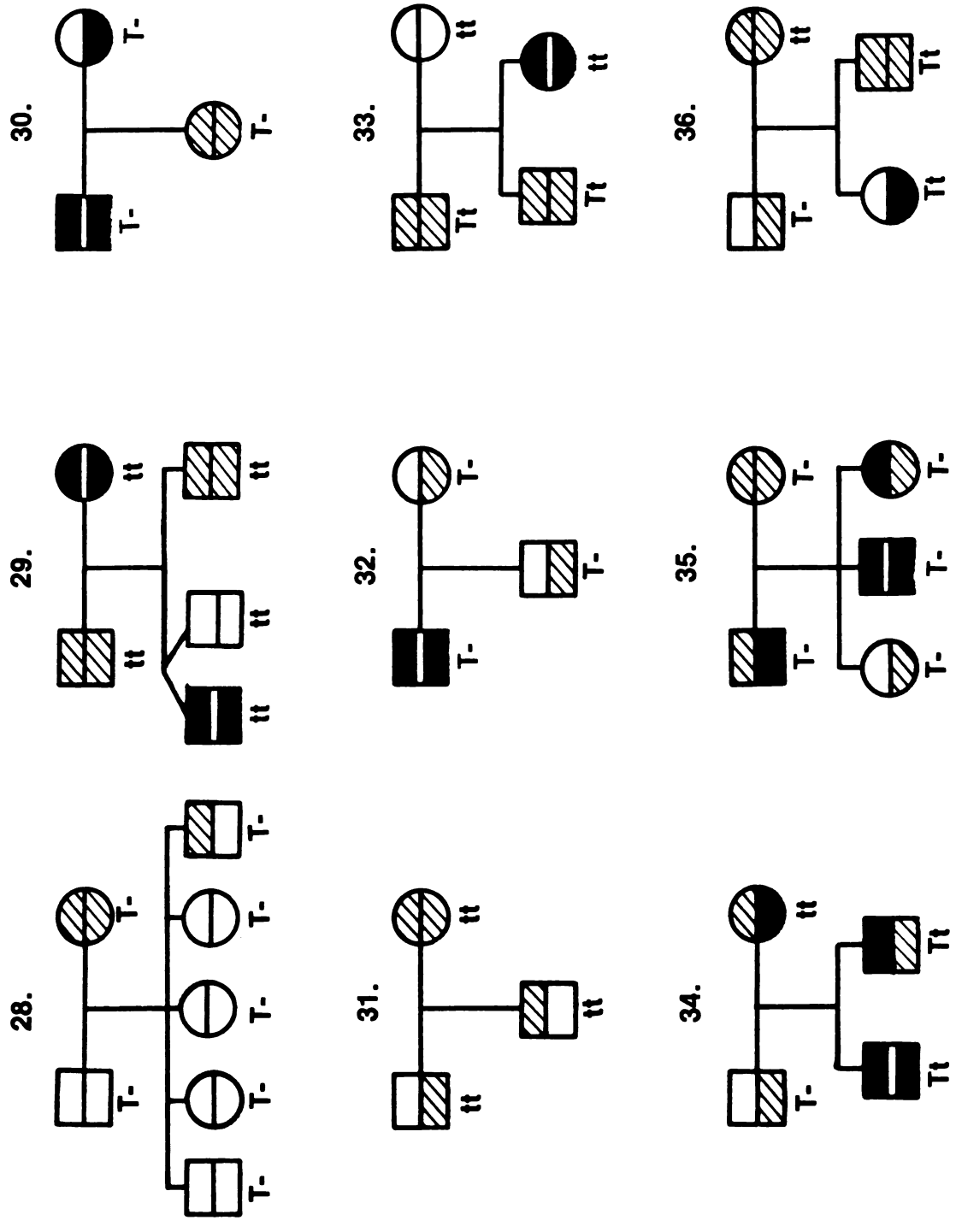
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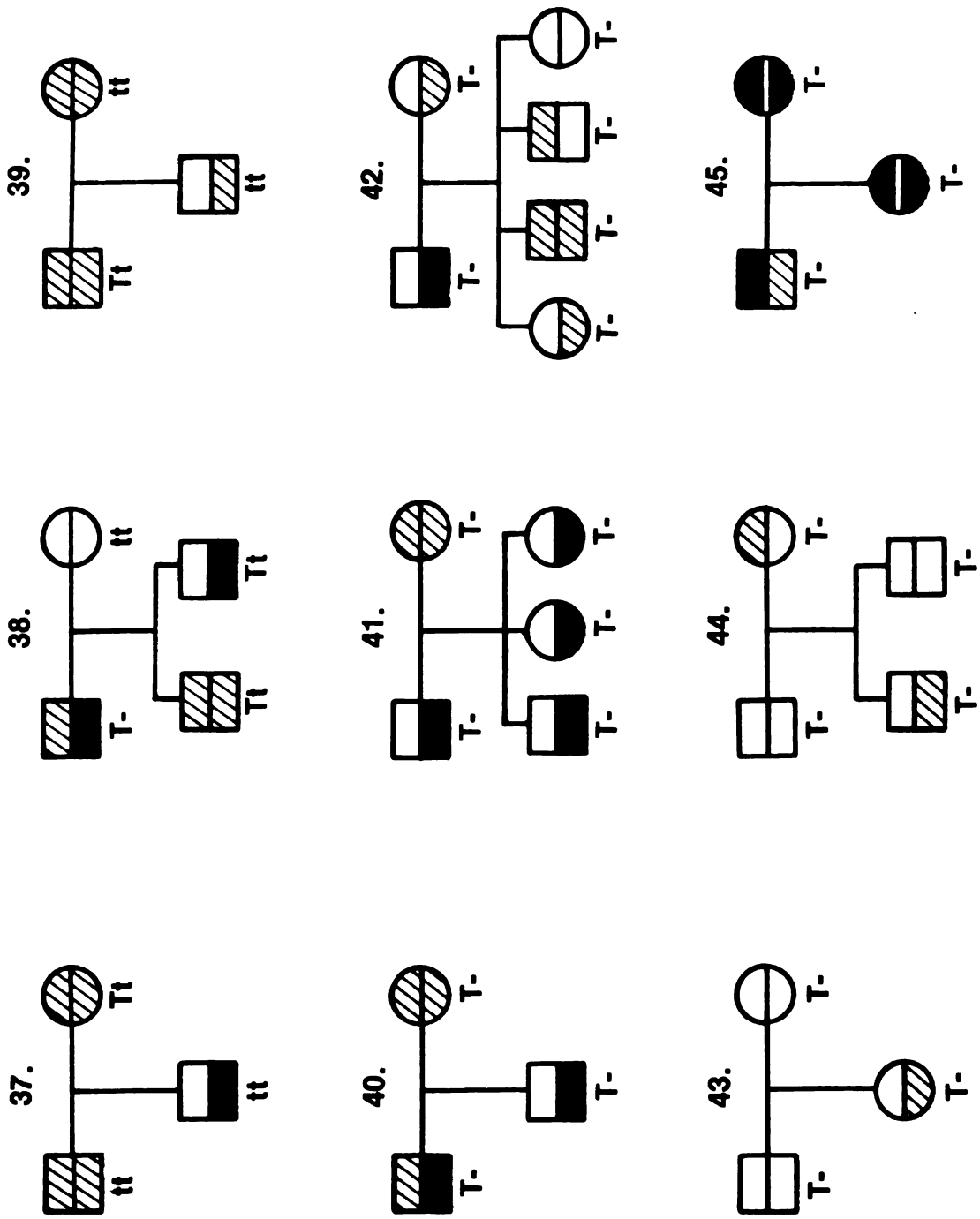
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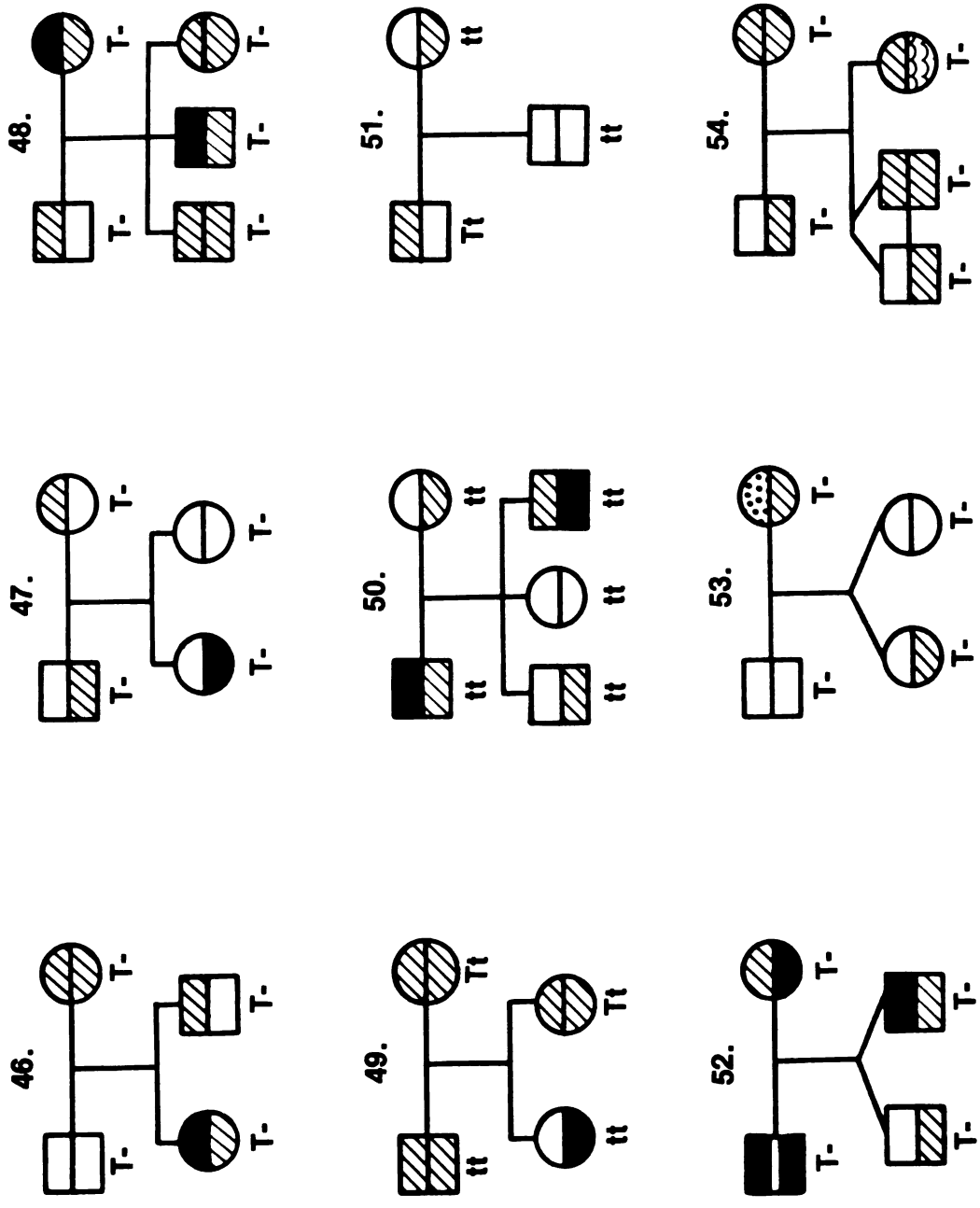
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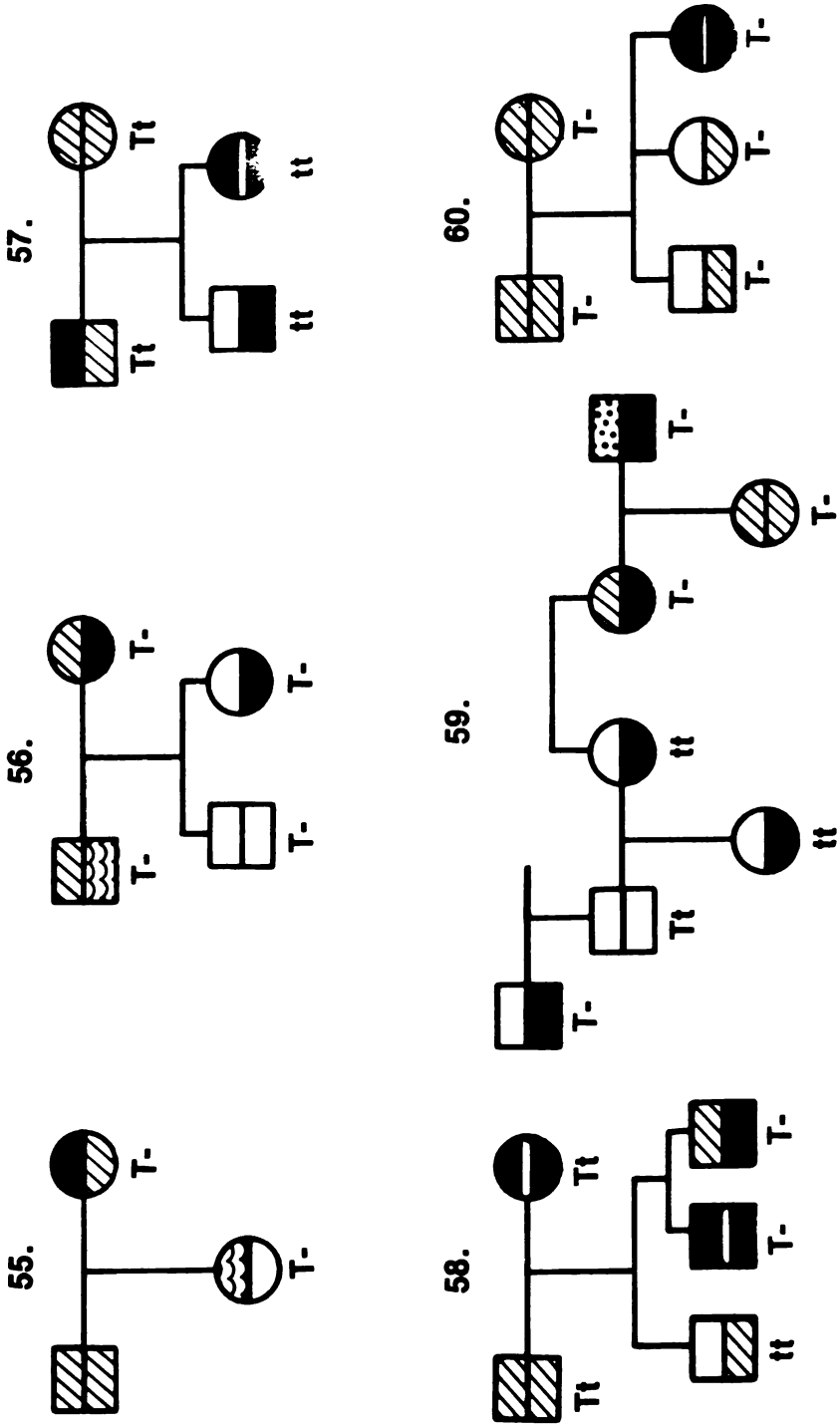
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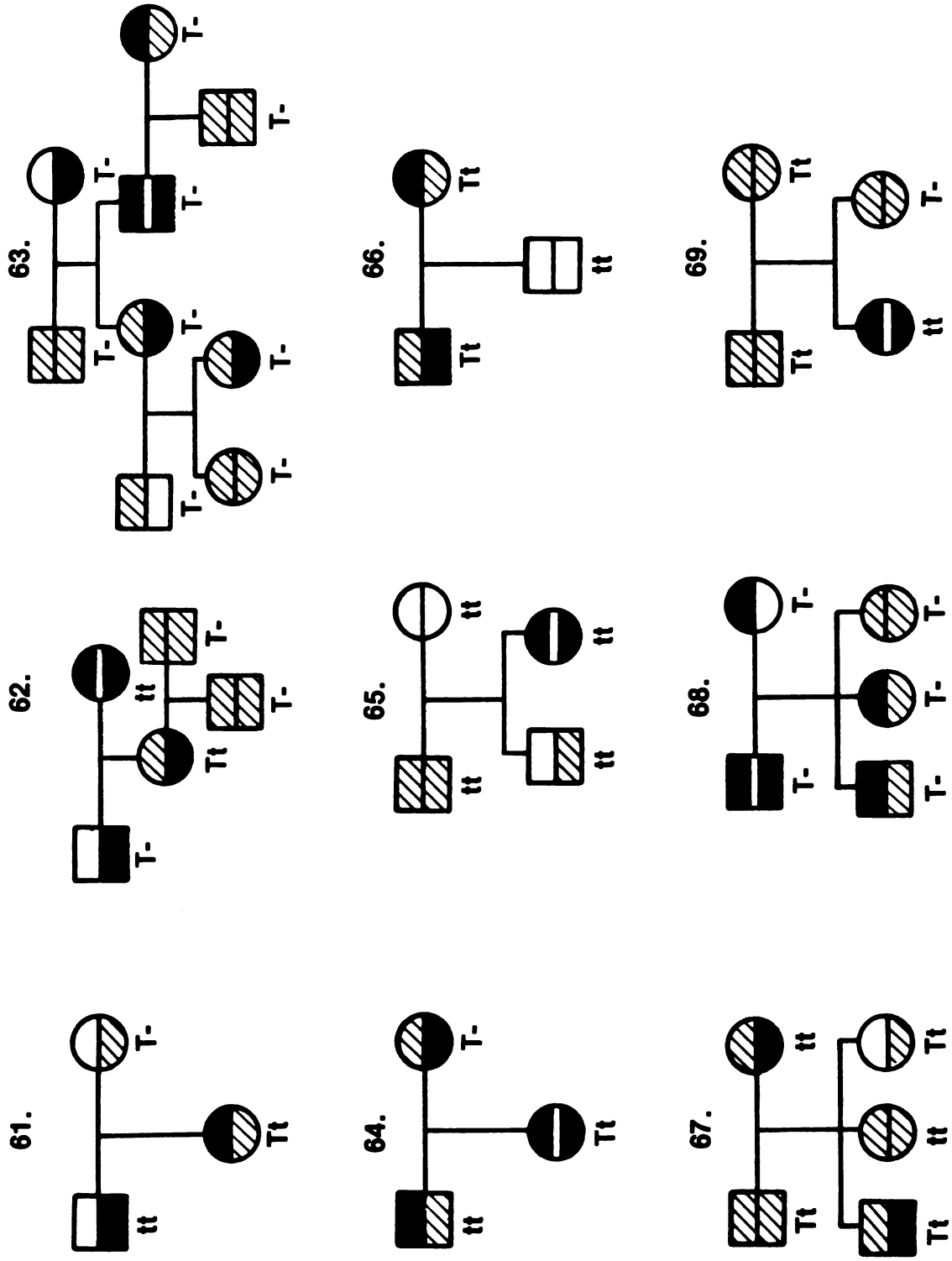
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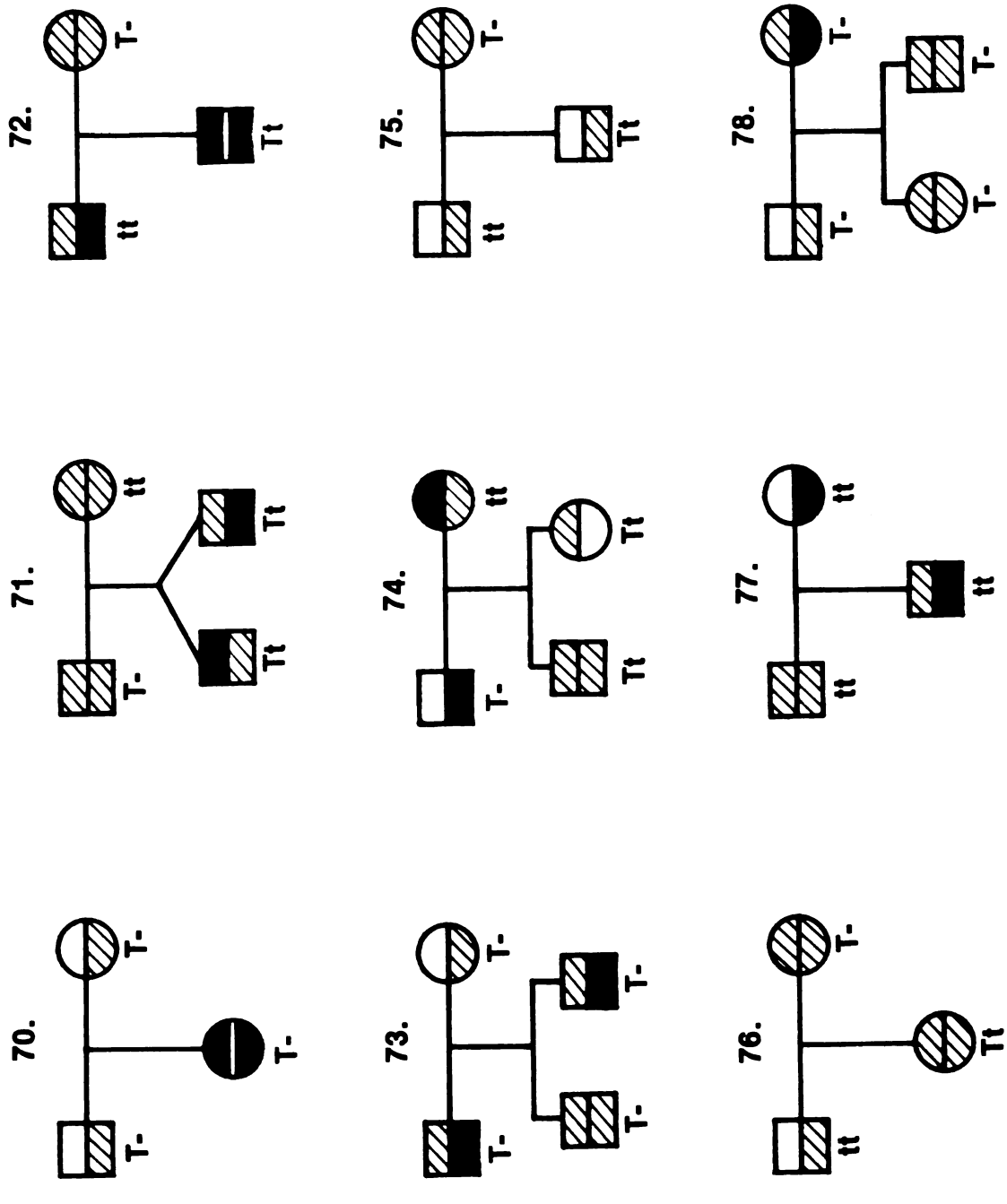
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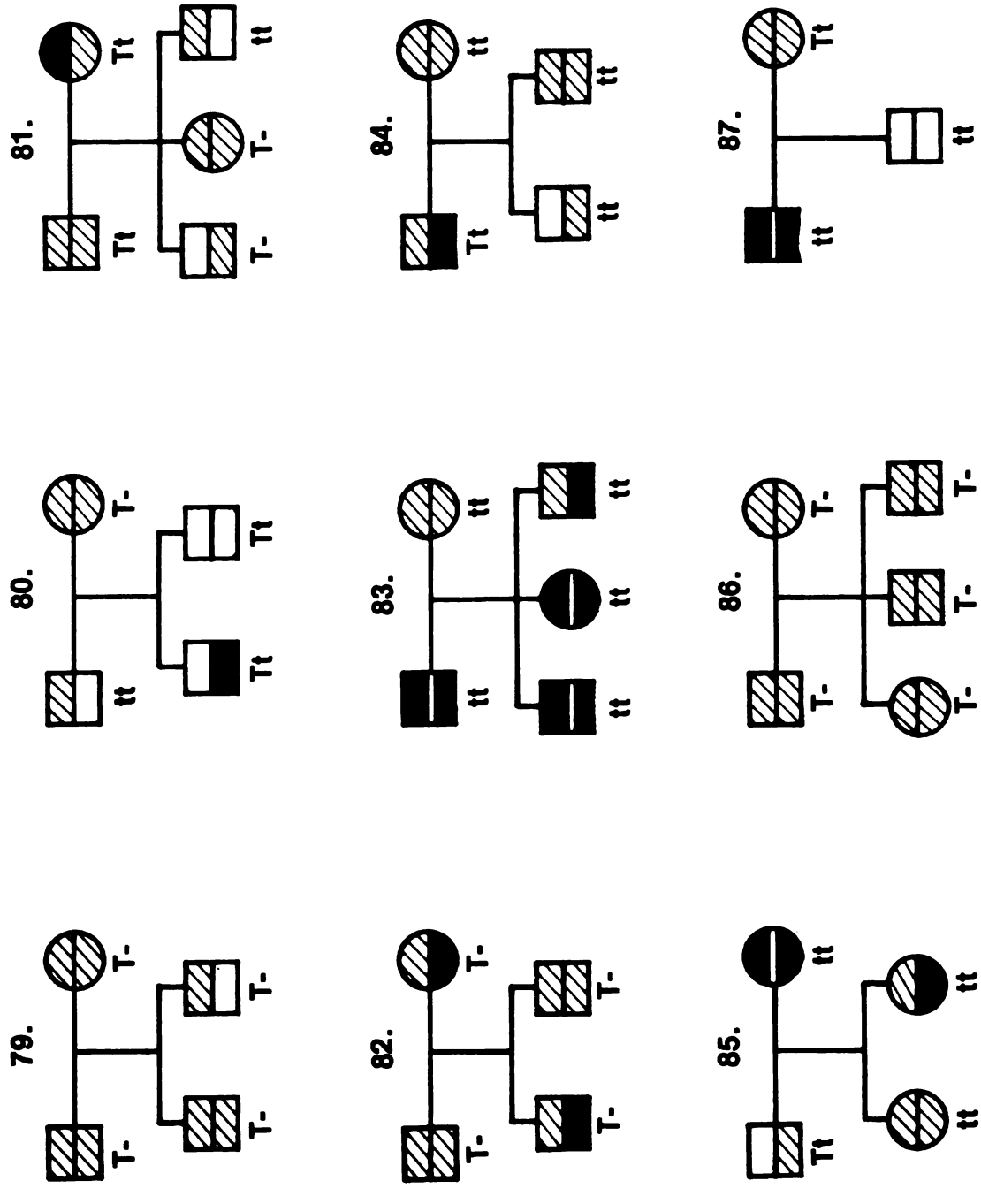
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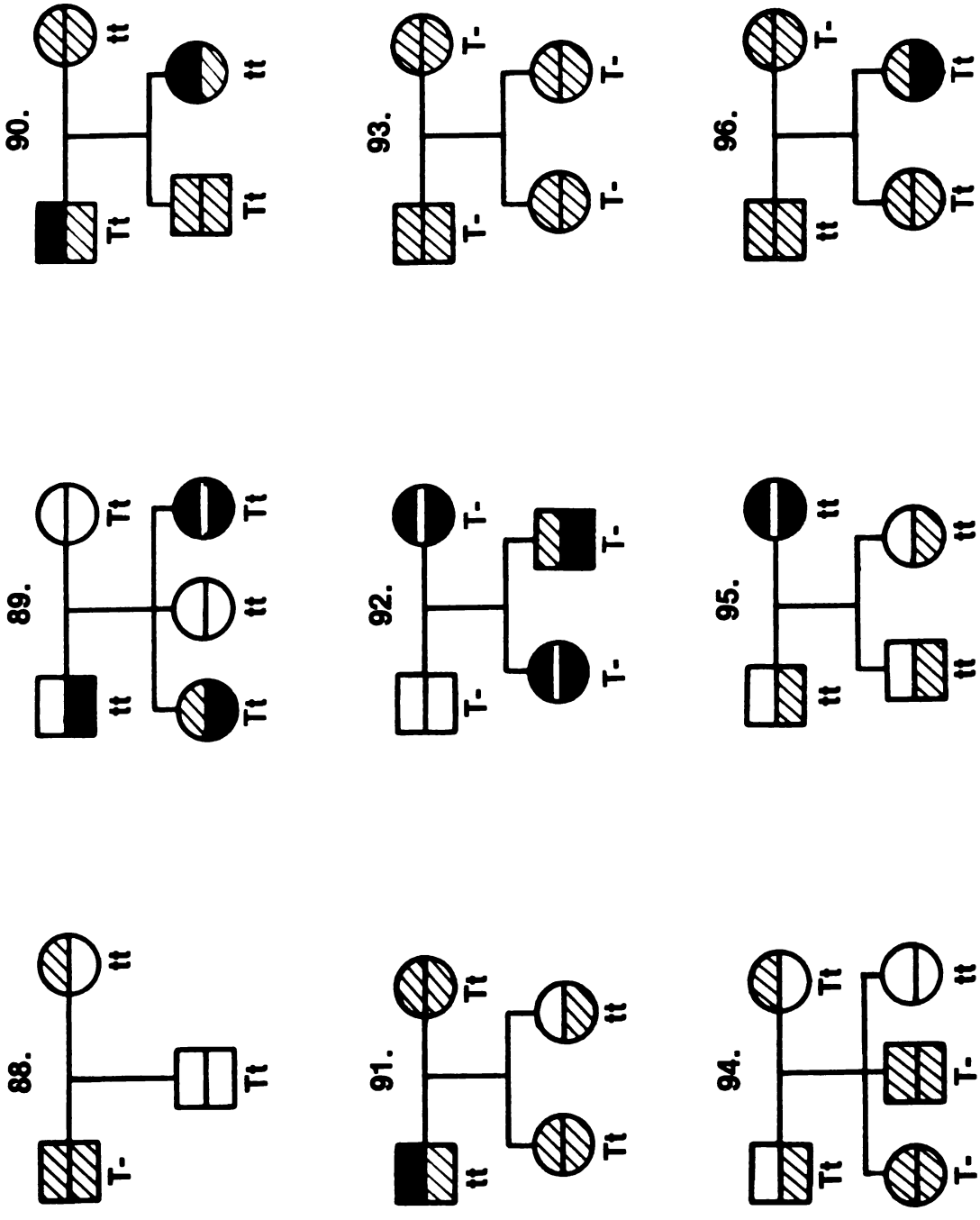
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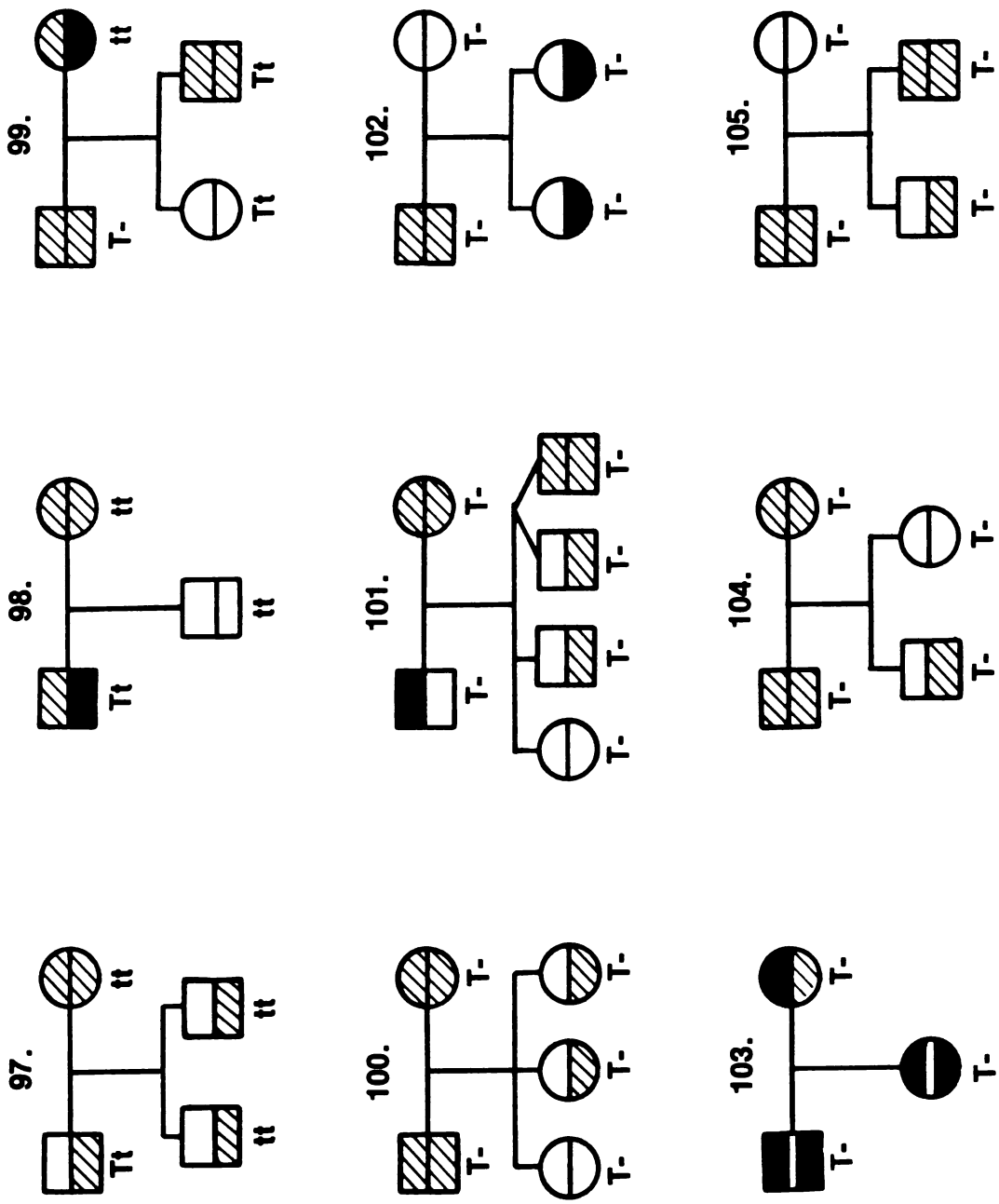
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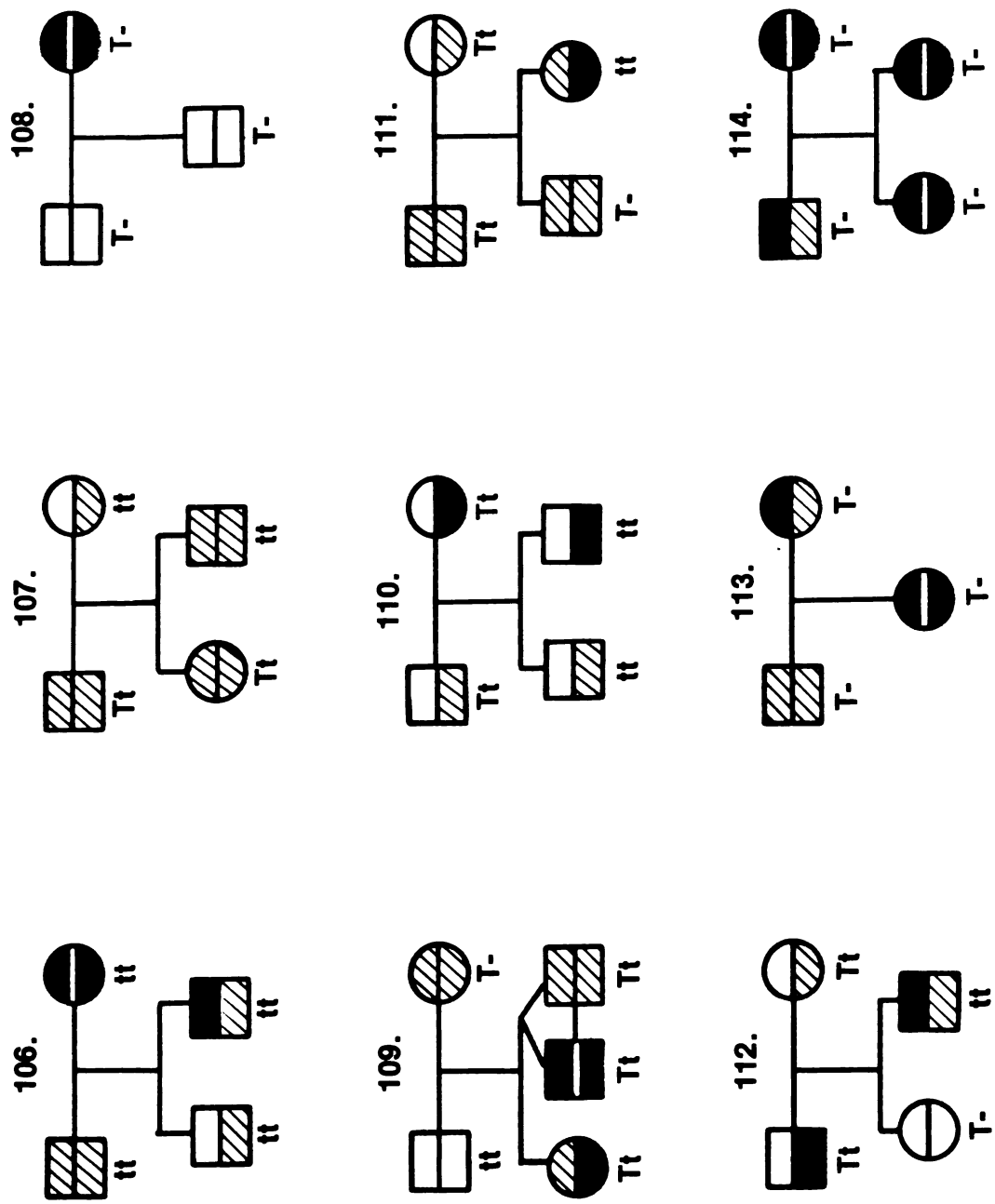
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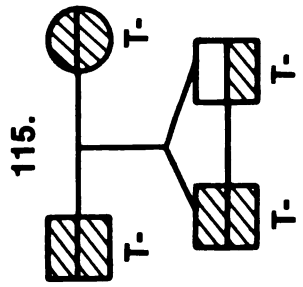
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Table 28.--Family Studies: PTC Taster-Nontaster Perceptions.

Mating Types	No.	Offspring		Total	Observed Nontaster Proportion	Expected Nontaster Proportion*
		Taster	Nontaster			
Taster x Taster	67	123	14	137	0.1022	0.1099
Taster x Nontaster	35	42	19	61	0.3115	0.3315
Nontaster x Nontaster	10	0	21	21	1.0000	1.0000
Total	112	165	54	219		

*Based on Snyder's ratios to test hypothesis: PTC Nontasting is Recessive.

Test of Randomness for Data Presented:

$\chi_2^2 = 80.89$, $p << 0.05$

Examples of Calculations:

To estimate q^2 using total frequency of Nontasters:

2(10) + 35 = 55 Nontaster Parents
+ 54 Nontaster Offspring
109

Since total sample in this case = 443 (224 parents + 219 offspring)

$q^2 = \frac{109}{443} = 0.246$ and $q = \sqrt{0.246} = 0.496$

Expected proportion of Nontaster Offspring from Taster x Taster Matings: (by Snyder's ratios)

$$S_2 = \frac{q^2}{(1+q)^2} = \frac{0.246}{(1.496)^2} = 0.1099$$

Expected proportion of Nontaster Offspring from Taster x Nontaster Matings:

$$S_1 = \frac{q}{1+q} = \frac{0.496}{1.496} = 0.3315$$

Expected proportion of Nontaster Offspring from Nontaster x Nontaster Matings (assuming Nontasting is recessive):

$S_o = 1.0$

To test the difference between Observed and Expected Proportions of nontaster offspring from various mating types using the Z transformation:

For Taster x Taster Matings:

$$Z_2 = \frac{0.1022 - 0.1099}{\sqrt{\frac{0.1022(1-0.1022)}{137}}} = -\frac{0.0077}{0.0259} = -0.2973$$

Since Z is negative number:

$F(z) = \alpha/2 = 0.38591$ thus $\alpha = 0.79182$

Confidence in rejecting hypothesis = $1 - \alpha = 1 - 0.79182 = 0.20818$

For Taster x Nontaster Matings:

$$Z_1 = \frac{0.3115 - 0.3315}{\sqrt{\frac{0.3115(1-0.3115)}{61}}} = -\frac{0.02}{0.0593} = -0.3373$$

$F(z) = \alpha/2 = 0.36693$ thus $\alpha = 0.73386$

Confidence in rejecting hypothesis = $1 - \alpha = 1 - 0.73386 = 0.26614$

For Nontaster x Nontaster Matings:

$$Z_o = \frac{1 - 1}{\sqrt{\frac{1(1-1)}{21}}} = 0$$

$F(z) = \alpha/2 = 0.5000$ $\alpha = 1.0$

Confidence in rejecting hypothesis = $1 - \alpha = 1.0 - 1.0 = 0$

Combined Evidence - Conversion to χ^2 to give probability of accepting hypothesis:

$$\chi^2 = -2[\Sigma \log_e \alpha]$$

$$\chi^2 = -2 [\log_e 0.792 + \log_e 0.0734 + \log_e 1]$$

$$= -2 [-0.23319 - 0.30923 - 0]$$

$$\chi^2_o = 1.08488^*$$

$p > 0.95$

*Two degrees of freedom per α.

types (see examples of calculations). These were compared to observed proportions of nontaster offspring obtained by use the Z-transformation to produce α values and subsequent statements of confidence in rejecting the hypothesis (for explanation of this procedure, see Appendix). Evidence from each of the mating types and their offspring were combined and converted to a Chi-square value. As can be seen, the data are consistent with the hypothesis proposed ($p > 0.95$).

Analysis of Family Antidesma Perception Data (Two Generation Families)

Results obtained from dichotomous classifications of offspring of various matings for each of the major taste perceptions of Antidesma (bitter versus nonbitter, sweet versus nonsweet, etc.) were analyzed by the same procedures used in analysis of the PTC data. In each case, initial analysis was performed to decide if data obtained were consistent with a random hypothesis then subsequently analyzed to determine if a dominant-recessive hypothesis could account for observed results. For purposes of testing this genetic hypothesis, in each case the assumption was made that the basic taste perceptions (bitter, sweet, sour) were recessive. This was done because in the majority of cases, inspection of family pedigrees suggested that this assumption was the most feasible.

Family data obtained for bitter-nonbitter perceptions of Antidesma I are reported in Table 29. The test of randomness for observed and expected frequencies of these perceptions for the offspring shows that the differences were significant ($p < 0.05$). Test of the genetic hypothesis that bitter perceptions of Antidesma I are recessive

Table 29.--Family Studies: Antidesma I Bitter-Nonbitter Perceptions.

Mating Types	No.	Offspring		Total	Observed Bitter Proportion	Expected Bitter Proportion
		Nonbitter	Bitter			
Nonbitter x Nonbitter	78	135	18	153	0.1176	0.0874
Nonbitter x Bitter	29	43	14	57	0.2456	0.2956
Bitter x Bitter	5	2	7	9	0.7778	1.0000
Total	112	180	39	219		

Test of Randomness of Bitter-Nonbitter Perceptions of Offspring:

$\chi_2^2 = 27.76, p < 0.05$

Test of Genetic Hypothesis: Bitter Perception is Recessive

$q^2 = 0.1761, \quad q = 0.4196$

Expected proportion of "Bitter" offspring from Nonbitter x Nonbitter Matings

$$S_2 = \frac{q^2}{(1+q)^2} = 0.0874$$

Expected proportion of "Bitter" offspring from Nonbitter x Bitter Matings

$$S_1 = \frac{q}{1+q} = 0.2956$$

Expected proportion of "Bitter" offspring from Bitter x Bitter Matings given bitter is recessive:

$S_0 = 1.0$

To test the difference between Observed and Expected Proportions of "Bitter" offspring from various mating types using the Z transformation:

For Nonbitter x Nonbitter Matings

$Z_2 = 1.1615, \quad F(z) = 0.87698$

Since Z is positive number:

$1 - F(z) = \alpha/2 = 1.0 - 0.87698 = 0.123$ therefore $\alpha = 0.246$

Confidence in rejecting hypothesis: $1.0 - \alpha = 1 - 0.246 = 0.754$

For Nonbitter x Bitter Matings

$Z_1 = -0.8772.$ sinxe z is negative number:

$F(z) = \alpha/2 = 0.18943$ thus $\alpha = 0.37886$

Confidence in rejecting hypothesis: $1 - \alpha = 1 - 0.37886 = 0.62114$

For Bitter x Bitter Matings

$Z_0 = -1.6032$

$F(z) = \alpha/2 = 0.05480$ thus $\alpha = 0.1096$

Confidence in rejecting hypothesis: $1 - \alpha = 1 - 0.1096 = 0.8904$

Combined Evidence - Conversion to χ^2 to give probability that data conforms to proposed hypothesis:

$$\chi^2 = -2[\Sigma \log_e \alpha]$$

$$= -2[\log_e 0.246 + \log_e 0.379 + \log_e 0.11]$$

$$= -2[-1.40242 - 0.97022 - 2.20727]$$

$$\chi^2_6 = 9.1598$$

$$0.5 > p > 0.1$$

and nonbitter is dominant resulted in a probability of 0.1 to 0.5 thus this hypothesis cannot be refuted.

Results obtained for sweet-nonsweet and sour-nonsour perceptions of Antidesma I for the various mating combinations and offspring produced are tabulated in Tables 30 and 31. Although initial Chi-square analysis suggested that these results were random, genetic analyses were still performed. As expected, when such analyses were carried out, the combined evidence strongly suggested that these perceptions of Antidesma I do not conform to the proposed genetic hypothesis.

Family data for bitter-nonbitter, sweet-nonsweet and sour-nonsour perceptions of Antidesma II are reported in Tables 32-34. It can be seen that in each case, the test of randomness by Chi-square suggests that these data are not random ($p < 0.05$). The combined evidence from subsequent genetic analysis of the various mating types for each of these perceptions of Antidesma II however, strongly suggests that it is unlikely that they conform to the dominant-recessive hypothesis proposed ($p < 0.05$).

Analysis of Taste Perceptions from Three-Generation Family Data

From Figure 5, it is apparent that families numbered 59, 62 and 63 include three generation taste perception data. Because of the limited number of these types of families and the absence of information for several first generation members, these data were not conducive to detailed analyses.

With respect to perceptions of PTC as can be seen, there were no exceptions observed which were inconsistent with the previously accepted hypothesis of dominance for PTC tasting and recessivity for

Table 30.--Family Studies: Antidesma I Sweet-Nonsweet Perceptions.

Mating Types	No.	Offspring		Total	Observed Sweet Proportion	Expected Sweet Proportion
		Nonsweet	Sweet			
Nonsweet x Nonsweet	55	67	42	109	0.3853	0.1431
Nonsweet x Sweet	46	48	43	91	0.4725	0.3783
Sweet x Sweet	11	8	11	19	0.5789	1.0000
Total	112	123	96	219		

Test of Randomness of Sweet-Nonsweet Perceptions of Offspring:

$$\chi_2^2 = 3.2049,\ p > 0.05$$

Test of Genetic Hypothesis: Sweet Perception is Recessive

$q^2 = 0.3702$ $q = 0.6084$

$S_2 = 0.1431$ $S_1 = 0.3783$ $S_0 = 1.0000$

For Nonsweet x Nonsweet Matings

$Z_2 = 5.197$ $F(Z) = 0.99999997133$ $\alpha \simeq 0$

Confidence in rejecting hypothesis $\simeq 1.0$

For Nonsweet x Sweet Matings

$Z_1 = 1.801$ $F(Z) = 0.96407$ $\alpha = 0.0718$

Confidence in rejecting hypothesis = 0.9282

For Sweet x Sweet Matings

$Z_0 = -3.72$ $F(Z) = 0.00010$ $\alpha = 0.0002$

Confidence in rejecting hypothesis = 0.9998

Combined Evidence - Conversion to χ^2 to give probability that Antidesma I Sweet perceptions conform to recessive hypothesis:

$$\chi_6^2 = 33.2621,\ p << 0.005$$

Note: This Chi-square value and others like it is an approximation since natural logs for two α values could not be determined from published natural logarithm tables,

$$\log_e 0 = \infty \text{ and } \log_e 0.001 = -6.90776$$

Thus for values of $\alpha = 0$ and $\alpha = 0.0002$, natural log value used in Chi-square calculation was -7.0 for both of these α values.

Table 31.--Family Studies: Antidesma I Sour-Nonsour Perceptions.

Mating Types	No.	Offspring		Total	Proportion of Sour Observed	Proportion of Sour Expected
		Nonsour	Sour			
Nonsour x Nonsour	29	39	13	52	0.25	0.159
Nonsour x Sour	52	63	43	106	0.4057	0.399
Sour x Sour	31	36	25	61	0.4098	1.000
Total	112	138	81	219		

Test of Randomness of Sour-Nonsour Perceptions of Offspring:

$$\chi_2^2 = 4.2081, \quad p > 0.05$$

Test of Genetic Hypothesis: Sour Perception is Recessive

$q^2 = 0.440$ $q = 0.663$

$S_2 = 0.159$ $S_1 = 0.399$ $S_0 = 1.000$

For Nonsour x Nonsour Matings

$Z_2 = 1.52$ $F(z) = 0.9357$ $\alpha = 0.1285$

Confidence in rejecting hypothesis = 0.87148

For Nonsour x Sour Matings

$Z_1 = 0.14$ $F(z) = 0.5557$ $\alpha = 0.8887$

Confidence in rejecting hypothesis is = 0.11134

For Sour x Sour Matings

$Z_0 = -9.368$ $F(z) = \simeq 0$ $\alpha \simeq 0$

Confidence in rejecting hypothesis $\simeq 1.0$

Combined Evidence - Conversion to χ^2 to give probability that Antidesma I Sour perceptions conform to Recessive hypothesis:

$$\chi_6^2 = 18.3311, \quad p < 0.01$$

Table 32.--Family Studies: Antidesma II Bitter-Nonbitter Perceptions.

Mating Types	No.	Offspring		Total	Proportion of Bitter Observed	Proportion of Bitter Expected
		Nonbitter	Bitter			
Nonbitter x Nonbitter	64	100	27	127	0.2126	0.1669
Nonbitter x Bitter	43	46	37	83	0.4458	0.3414
Bitter x Bitter	5	7	2	9	0.2222	1.0000
Total	112	153	66	219		

Test of Randomness of Bitter-Nonbitter Perceptions of Offspring

$$\chi^2_2 = 13.245, \quad p < 0.05$$

Test of Genetic Hypothesis: Bitter Perception is Recessive

$q^2 = 0.2686$ $q = 0.5183$

$S_2 = 0.1669$ $S_1 = 0.3414$ $S_0 = 1.0000$

For Nonbitter x Nonbitter Matings

$Z_2 = 1.26$ $F(z) = 0.89617$ $\alpha = 0.2166$

Confidence in rejecting hypothesis = 0.7834

For Nonbitter x Bitter Matings

$Z_1 = 1.91$ $F(z) = 0.97193$ $\alpha = 0.0561$

Confidence in rejecting hypothesis = 0.9439

For Bitter x Bitter Matings

$Z_0 = -5.6118$ $F(z) = 2.87 \times 10^{-7}$ $\alpha = 5.74 \times 10^{-7}$

Confidence in rejecting hypothesis = 0.999995

Combined Evidence - Conversion to χ^2 to give probability that Antidesma II Bitter perceptions conform to Recessive hypothesis:

$$\chi^2_6 = 20.821, \quad p < 0.005$$

Table 33.--Family Studies: Antidesma II Sweet-Nonsweet Perceptions.

Mating Types	No.	Offerspring		Total	Proportion of Sweet Observed	Proportion of Sweet Expected
		Nonsweet	Sweet			
Nonsweet x Nonsweet	83	135	20	155	0.1290	0.0842
Nonsweet x Sweet	27	39	22	61	0.3607	0.2901
Sweet x Sweet	2	2	1	3	0.3333	1.0000
Total	112	176	43	219		

Test of Randomness of Sweet-Nonsweet Perceptions of Offersing

$$\chi_2^2 = 15.2375, \quad p < 0.05$$

Test of Genetic Hypothesis: Sweet Perception is Recessive

$q^2 = 0.167$ $q = 0.4087$

$S_2 = 0.0842$ $S_1 = 0.2901$ $S_0 = 1.0000$

For Nonsweet x Nonsweet Matings

$Z_2 = 1.665$ $F(z) = 0.95254$ $\alpha = 0.0949$

Confidence in rejecting hypothesis = 0.9051

For Nonsweet x Sweet Matings

$Z_1 = 1.148$ $F(z) = 0.87493$ $\alpha = 0.2501$

Confidence in rejecting hypothesis = 0.7499

For Sweet x Sweet Matings

$Z_0 = -2.449$ $F(z) = 0.00714$ $\alpha = 0.0143$

Confidence in rejecting hypothesis = 0.9857

Combined Evidence - Conversion to χ^2 to give probability that Antidesma II Sweet Perception conform to Recessive hypothesis:

$\chi_6^2 = 16.0177, \; p < 0.02$

Table 34.--Family Studies: Antidesma II Sour-Nonsour Perceptions.

Mating Types	No.	Offspring		Total	Proportion Of Sour Observed	Proportion Of Sour Expected
		Nonsour	Sour			
Nonsour x Nonsour	13	12	13	25	0.520	0.1822
Nonsour x Sour	60	71	51	122	0.4180	0.4269
Sour x Sour	39	28	44	72	0.6111	1.0000
Total	112	111	108	219		

Test of Randomness of Sour-Nonsour Perceptions of Offspring

$\chi_2^2 = 6.8337$, $p < 0.05$

Text of Genetic Hypothesis: Sour is Recessive

$q^2 = 0.555$ $q = 0.745$

$S_2 = 0.1822$ $S_1 = 0.4269$ $S_0 = 1.0000$

For Nonsour x Nonsour Matings

$Z_2 = 3.381$ $F(z) = 0.99964$ $\alpha = 0.00072$

Confidence in rejecting hypothesis = 0.99928

For Nonsour x Sour Matings

$Z_1 = -0.1991$ $F(z) = 0.42074$ $\alpha = 0.84148$

Confidence in rejecting hypothesis = 0.15852

Four Sour x Sour Matings

$Z_0 = -6.765$ $F(z) = 10^{-10}$ $\alpha = 20^{-10} \simeq 0$

Confidence in rejecting hypothesis $\simeq$ 1.0

nontasting. Further inspection of these pedigrees however, shows that the results obtained for Antidesma taste perceptions are ambiguous, in that there are some instances which provide evidence in support of the hypothesis that certain basic taste qualities may be consistent with a recessive inheritance mode. In other instances there is evidence to the contrary. For example, in family #59, the left side of the pedigree is consistent with the hypothesis that the sweet perception of Antidesma I may be recessive. Furthermore, in families #62 and #63, there is evidence to suggest that sour perceptions of Antidesma I may be inherited as a recessive trait. It may be recalled however from analyses of the two generation family data that these hypotheses were untenable and that the only hypothesis which had some measure of support was that suggesting recessivity for the bitter perception of Antidesma I. This latter hypothesis however, is not supported by data from family #63 (right side of pedigree) in which a bitter x bitter mating produced a nonbitter offspring.

With respect to taste perceptions of Antidesma II, it may also be recalled that the dominant-recessive hypotheses for each of the taste responses were rejected with a high degree of confidence based on the two generation data. While the three-generation data may in some instances support this previous premise as in family #59 (right side of pedigree) where an Antidesma II bitter x bitter mating produced a nonbitter offspring, data from family #62 may suggest otherwise (Antidesma II bitter x bitter mating produced a bitter offspring). Other three-generation data provides no further elucidation of possible dominant-recessive mode of inheritance for specific taste perceptions of Antidesma I or Antidesma II.

Analysis of Taste Perceptions of Twins

As previously reported, this study included taste perceptions of twelve pairs of twins. Although zygosity was not confirmed by direct serological determinations, according to statements made by parents of these individuals, there were five monozygous and seven dizygous twin pairs. Additionally, as was the case with the three-generation family data, the limited number of twins sampled precluded detailed analyses.

Taste perceptions of the three concentrations of PTC and the two Antidesma solutions as reported by twins are recorded in Table 35. As shown, for each of the PTC concentrations, monozygous (MZ) as well as dizygous (DZ) twins most often judged these solutions as bitter. For MZ twins, the only other taste quality reported for the low and medium PTC concentrations was tasteless and none of them found the high concentration tasteless. A substantial number of DZ twins recorded the tasteless perception for all three concentrations of PTC and two of these twins reported salty and sour perceptions. It is interesting to note that in the latter case, a DZ twin perceived the low and high PTC concentration as sour but judged the medium concentration as bitter.

With regards to perceptions of the Antidesma solutions, none of the twins judged either of these as tasteless or salty. For Antidesma I, MZ twins most often perceived this as sweet or sour. Similarly, DZ twins often responded sweet or sour to this solution but an appreciable number (four of fourteen) also found it bitter. Perceptions of Antidesma II of MZ twins were either sour or bitter while DZ twins reported these as well as sweet perceptions. When the above perceptions of PTC and Antidesma for MZ and DZ twins were compared, no significant differences were observed for these groups ($p > 0.05$).

Table 35.--Taste Perceptions of PTC and Antidesma of Twins.

	PTC						Antidesma			
	Low Conc.		Med. Conc.		High Conc.		Antidesma I		Antidesma II	
	*MZ	DZ	MZ	DZ	MZ	DZ	MZ	DZ	MZ	DZ
Tasteless	3	5	1	5	0	4	0	0	0	0
Sour	0	1	0	0	0	1	4	4	8	8
Sweet	0	0	0	0	0	0	5	6	0	2
Bitter	7	7	9	8	10	8	1	4	2	4
Salty	0	1	0	1	0	1	0	0	0	0
Total	10	14	10	14	10	14	10	14	10	14

*MZ = Assumed Monzygous Twins
DZ = Assumed Dizygous Twins

PTC Low (20.31 mg/l): $\chi^2_3 = 1.91$, $p > 0.05$

PTC Med (40.63 mg/l): $\chi^2_2 = 3.16$, $p > 0.05$

PTC High (81.25 mg/l): $\chi^2_3 = 5.74$, $p > 0.05$

Antidesma I: $\chi^2_2 = 1.26$, $p > 0.05$

Antidesma II: $\chi^2_2 = 2.05$, $p > 0.05$

To possibly elucidate the relative role of genetic factors in determining taste perceptions, concordance rates for MZ and DZ twins were computed and compared. These rates for each of the PTC solutions are reported in Table 36a. As indicated, the concordance frequencies have been calculated for the overall (actual) PTC perceptions as well as those for bitter-nonbitter and taster-nontaster perceptions. As can be observed, concordance rates for MZ twins are the same for each of the three types of computations for a given PTC concentration and with the exception of the taster-nontaster classification, were higher than those of DZ twins. When this latter dichotomy was employed, four of the five MZ twins reported identical perceptions for the low and medium PTC concentrations for concordance rates of 0.8. This may be contrasted with a concordance rate of 0.857 for DZ twins for these same solutions. It should be noted however, that this value, unlike that of the MZ twins was derived not from identical taste perceptions in these twins but from their classification as nontasters or tasters (regardless of taste perception recorded). A similar situation was observed for the high PTC concentration in which the concordance rate for both MZ and DZ twins was 1.0. While each of the MZ twin pairs perceived this solution as bitter, in two separate instances one member of a DZ pair responded bitter while the other member of the pair judged the solution as sour or salty. Since by definition all of these individuals were considered tasters however, the concordance rate of 1.0 for the MZ and DZ twins may not be strictly comparable.

For purposes of testing equivalence of concordance rates for taste perceptions of monozygous and dizygous twin pairs, Fisher's Exact Probability Test was employed (for rationale and explanation of this

Table 36a.--PTC Taste Perceptions of Twins: Concordance Rates.

	Overall (Actual) Perceptions		Bitter-Nonbitter Perceptions		Taster-Nontaster Perceptions	
	MZ	DZ	MZ	DZ	MZ	DZ
PTC (Low)	0.8	0.571	0.8	0.571	0.8	0.857
PTC (Med)	0.8	0.714	0.8	0.714	0.8	0.857
PTC (High)	1.0	0.714	1.0	0.714	1.0	1.0
Fisher's Exact Probability:	PTC Low: p = 0.354 PTC Med: p = 0.477 PTC High: p = 0.318		p = 0.354 p = 0.477 p = 0.318		p = 0.530 p = 0.530 p = 1.0	

procedure, see Appendix). When this test was applied to these concordance rates for overall, bitter-nonbitter and taster-nontaster perceptions for each concentration of PTC as reported in Table 36a, differences between the twin types were not significant ($p > 0.05$).

Concordance rates for Antidesma taste perceptions of twins are presented in Table 36b. As can be observed, these rates have been computed for the actual perceptions reported as well as for bitter-nonbitter perceptions. With respect to the overall taste perceptions of Antidesma I and II, concordance rates for monozygous twins were somewhat higher than those of dizygous twins. For the bitter-nonbitter perceptions, MZ twins were also concordant more often than the DZ twins for Antidesma I but not for Antidesma II. Comparisons of the concordance rates for each of the Antidesma solutions however, revealed no significant differences between these rates for the two twin groups ($p > 0.05$).

Table 36b.--Antidesma Taste Perceptions of Twins: Concordance Rates.

	Overall (Actual) Perceptions		Bitter-Nonbitter Perceptions	
	MZ	DZ	MZ	DZ
Antidesma I	0.2	0.143	0.8	0.429
Antidesma II	0.6	0.571	0.6	0.714

Fisher's Exact Probability:	Antidesma I: p = 0.530	Antidesma I: p = 0.221
	Antidesma II: p = 0.442	Antidesma II: p = 0.424

DISCUSSION

That we do not all inhabit the same taste worlds is a commonly accepted phenomenon. To a great degree however, most variations in taste perceptions have traditionally been attributed to acquisition of preferences, of likes and dislikes of certain substances tasted gained via culture, custom and learning. The classic exceptions to these environmentally derived gustatory perceptional variation hypotheses have been the numerous population studies of taste responses to PTC and related compounds which clearly establish that genetic factors play an important role in determining certain taste perceptions. Recent investigations with other substances such as caffeine and saccharin have further called attention to the role of inherited factors in producing taste variations. Most of these substances, as previously noted, have been linked to PTC perceptions in some manner.

The present investigation, prompted by the reported association between taste perceptions of PTC and aqueous extracts from the fruit of Antidesma bunius, was designed to assess taste responses for these substances in a relatively large population study which included both unrelated individuals and family groupings. This investigation would thus provide opportunities to compare the PTC taste perception data obtained with those of previously reported studies, to study associations between PTC and Antidesma taste responses, to estimate population

frequencies for Antidesma responses by age, sex and racial groupings, to determine if taste perceptions of Antidesma are consistent with a simple dominant-recessive genetic hypothesis and to ascertain if additional factors such as smoking status and time of last food eaten are related to taste perceptions. Furthermore, by the inclusion of solutions as controls for various taste qualities (tasteless, salty, bitter, sweet and sour), information could be obtained to quantify differences in responses to substances which are typically perceived in a certain manner by a majority of human subjects.

Taste Perceptions of Controls

Because of the variability in taste quality identification previously reported in several gustatory investigations (Amerine et al., 1965; Meiselman and Dzendolet, 1967; Robinson, 1970), five solutions (lemon juice, 1 M sodium chloride, 0.001 M quinine sulfate, 0.5 M sucrose and distilled water) were included in the present study as controls for the taste qualities of sour, salty, bitter, sweet and tasteless. While assessment of taste perceptions for these controls was used primarily to determine the reliability of taste judgements for the experimental solutions (Antidesma and PTC), this also allowed estimations of the magnitude of the commonly recognized problem of misidentification of standards for the various taste qualities.

In the present study, the findings of misclassification rates of 17.9 percent for sour, 1.9 percent for tasteless, 2.5 percent for salty, 6.6 percent for bitter and 1.4 percent for sweet were much less than taste perceptual "errors" reported in previous investigations. In studies of untrained subjects using solutions containing similar

standard compounds, Meiselman and Dzendolet (1967) reported misclassification rates of 50 percent for sour, 29.15 percent for salty, 46.7 percent for bitter and 22.5 percent for sweet (no tasteless standard was used), while Robinson (1970) in a study of forty-eight subjects using only solutions of citric acid and quinine sulfate reported an error rate of 49 percent for sour and 37 percent for bitter. While strict comparisons of these investigations with the present study cannot be made because they employed lower solution concentrations nearer to the threshold levels, all of these studies, including the present one, show that the greatest tendency for misclassification occurred in the identification of sour and bitter (Table 1a).

Effects of age on perceptions of the four basic taste qualities have been noted by several researchers (Amerine et al., 1965). Such studies have been primarily concerned with determining taste sensitivity via measurements of taste thresholds and have included a variety of age groupings in comparing a wide range of ages. Thus, their utility for comparisons with the present investigation involving concentrations well above threshold levels would be limited. In most instances these previous age-taste studies have noted higher thresholds and hence decreased taste sensitivity for older subjects. Richter and Campbell (1940) reported that subjects between the ages of 52 and 85 had sucrose taste thresholds almost three times as great as those of subjects aged 15-19 years. Cooper et al. (1959) using subjects 15-89 years found that curves for the development and decline of sensitivity for the four basic taste qualities were essentially the same, in that a noticeable decline began in the late fifties although sour was less affected than the other tastes, while Aubek (1959) also observed significant decreases

in sensitivity in subjects of age 60 and above. The sharp decline in taste sensitivity with age as assessed by appropriate identification of control solutions was not confirmed in the present study since in most cases subjects of the older age groups (> 51 years) recorded less incorrect responses than those of younger ages, particularly when compared to ages 18-30 years (see Tables 6a and 6b). The apparent disparity in these results may be due to the use of more concentrated solutions which provided stimuli so far in excess of threshold levels so as to obscure any age effects which might have been noted.

Investigations which have examined basic taste quality sensitivity with respect to sex have produced conflicting results. A number of these studies have reported the lack of apparent sex differences in taste sensitivity (Aubek, 1959; Cooper et al., 1959; Krut et al., 1961). In contrast, other studies have suggested that females have greater taste acuity than males. Pangborn (1959) reported that in general, females have lower taste thresholds than males. Tilgner and Barylko-Pikielna (1959) found women to have a higher sensitivity than men for sweet and salty but less for sour and no difference between the sexes for bitterness. Studies by Meiselman and Dzendolet (1967) however, suggest that more males than females consistently confuse the sour and bitter taste qualities. Their work further suggests that except for the identification of sweet, males are less sensitive tasters in that they are more likely to misjudge standard control solutions when compared to females. Data from the present study is consistent with this latter finding (see Tables 9a and 9b) although these apparent sex differences in taste perception were not found to be statistically significant.

To determine whether a subject's membership in a specific race or ethnic group may contribute to differences in overall taste perceptions, an analysis of perceptions of controls by race was performed. There are apparently no previously published studies of this type with which to make comparisons. However, as indicated earlier, data obtained in this study have revealed no significant racial taste perceptional differences in responses to the control solutions for specific taste qualities. Thus individuals of different racial groups are just as likely to correctly or incorrectly identify the basic taste qualities (Tables 12a and 12b).

Despite the widespread belief that smoking decreases overall taste sensitivity, the experimental evidence is surprisingly inconclusive and/or discordant. Krut et al. (1961) have suggested that smokers are less sensitive to bitter, based on their finding of a significantly higher mean taste threshold of these subjects for solutions of quinine hydrochloride while the mean thresholds for control solutions for sweet, sour or salty were similar in smokers and nonsmokers. A similar insensitivity to bitter particularly in heavy smokers was also observed by Fischer et al. (1963). Furthermore, Peterson et al. (1968), in an extended study of smokers versus ex-smokers reported a significant decrease in taste thresholds (increased sensitivity) among ex-smokers after one month when compared to those who continued to smoke. In contrast to these findings, Cooper et al. (1959) observed no differences between smokers and nonsmokers in ability to detect any of the four primary tastes. McBurney and Moskat (1975) when measuring both detection and recognition thresholds of several compounds in smokers and nonsmokers found no consistent differences in either measure

between the two groups. While not precisely comparable with the above studies, taste acuity in smokers versus nonsmokers as assessed in the present study by appropriate responses to the control solutions is in agreement with these latter studies in that no significant associations of taste perception differences and smoking status were observed (Tables 15a and 15b).

The effects of hunger on taste sensitivity are uncertain. Yensen (1959) reported a significant decrease in sensitivity for about one hour after a meal followed by an increase in three or four hours. Similar findings have been suggested by some workers (Gusev, 1940) but have not been confirmed by others. Meyer (1952) for example, found no change in sensitivity to taste up to thirty-six hours of fasting. In the present investigation the comparison of taste responses to controls with time of last food eaten produced uniform results throughout each elapsed time category. This supports previous observations of a lack of change in general taste sensitivity with time since ingestion of last food (Tables 18a and 18b).

Taste Perceptions of PTC

Although data derived from numerous population studies indicate that the majority of human subjects perceived PTC as bitter or tasteless, other taste sensations for this compound have also been noted. Several researchers have found PTC perceptions of other taste qualities in addition to nontaste quality descriptions (e.g., camphory, sulfury). The reported incidence for sour PTC perceptions has been 2.3-5.4 percent, for sweet perceptions, 2.1-8.9 percent and for salty perceptions, 3.5-4.8 percent (Blakeslee and Fox, 1932; Blakeslee, 1935; Skude, 1959;

Skude, 1960; Richter and Clisby, 1941; Harris and Kalmus, 1949; Amerine et al., 1965). Corresponding values of these perceptions for the three PTC concentrations used in the present study as recorded in Table 4a, were 3.8-4.9 percent (sour), 0.09-0.3 percent (sweet), and 0.7-0.8 percent (salty). It will be noted that while the sour perceptions of PTC obtained in the present study compare favorably with those reported in previous investigations, the values obtained for sweet and salty PTC perceptions are lower than those previously reported. This discrepancy may be due to differences in testing procedures employed. For example, most of the previous studies included both lower and higher concentrations than those of the present study. It has been noted by some workers, that the incidence of "abberrant" PTC tasting (sensations other than bitter) increases at lower (subliminal) concentrations (Richter and Clisby, 1941; Skude, 1960; Rychokou and Borodina, 1973). This may also be true of instances where concentrations used are so high that some individuals who are in fact considered "nontasters," based on their perceptions of PTC solutions above the population antimode (81.25 mg/l), may have described taste sensations other than the bitter taste usually perceived.

The relationship between age and PTC taste sensitivity has been studied extensively but still remains uncertain due to the lack of agreement of published studies. Studies by Harris and Kalmus (1949) and Barnicot (1950) have suggested a deterioration in PTC taste sensitivity with age as evidenced by their finding of an increase in threshold perceptions of about one dilution step for each twenty years of age (e.g., 20.31 mg/l versus 40.63 mg/l) up to age fifty. Giles et al. (1968) and Ghosh (1973) have also reported marked fluctuations in

taster-nontaster frequencies with age but with no consistent age trends. Although several studies have noted some decreased PTC sensitivity with age, most have failed to confirm any significant age effects for threshold levels or PTC tasting status (Mohr, 1951; Paolucci et al., 1971; Alsbirk and Alsbirk, 1972; Bonne et al., 1972; Sriram et al., 1975; Ingley et al., 1976; Ibraimov et al., 1977). Results from the present study are in agreement with these latter findings in that no significant age differences in taste perceptions were found for any of the three PTC concentrations employed (Tables 8a and 8b).

Investigations of the relationship of sex and PTC tasting have produced fairly consistent results. As noted previously, females have been found to be more sensitive tasters in that they can detect PTC in higher dilutions than males. A few studies have reported this difference to be significant (Falconer, 1946; Montenegro, 1964; Giles et al., 1968; Scott-Emuakpor et al., 1975). Most reports however, have noted only nonsignificant threshold differences between the sexes (Hartman, 1939; Barnicot, 1950; Mohr, 1951; Soltan and Bracken, 1958; Bonne et al., 1972; Glaser, 1972; Than-Than-Sint and Mya-Tu, 1974; Ingley et al., 1976; Ibraimov et al., 1977; Tandon and Pandey, 1978). The present study is in general agreement with a majority of these reports since no significant associations of overall PTC perceptions with sex were found (Table 11a). Furthermore, despite the slightly greater frequency of female tasters, no significant differences in the sex-related proportions of tasters and nontasters were observed for each of the three PTC concentrations used (Table 11b). However, as also noted in Table 11b, when PTC perceptions were classified as bitter or nonbitter, significant sex differences were observed but only for the low

concentrations of PTC (20.31 mg/l). These findings along with others previously discussed suggest the need for further investigations of the relationship of sex and taste perceptions in general as well as sex, PTC taste sensitivity and bitter cognition in particular.

As indicated earlier, numerous population studies have noted considerable racial or ethnic differences for PTC perceptions. Most of these have indicated that Negroid, Mongoloid and American Indian populations are generally characterized by a nontaster frequency of less than 20 percent, while this figure in Caucasian populations is usually 25-35 percent (Lee, 1934; Cohen and Ogden, 1949; Barnicot, 1950; Lugg, 1966, 1968, 1970; Mohr, 1951; Monn, 1969; Sunderland, 1966; Sunderland and Rosa, 1975; Barnicot, 1950; Barnicot and Woodburn, 1975; Bhalia, 1972; Scott-Emuakpor et al., 1975; Frisancho et al., 1977; Bhalia, 1972; Allison and Blumberg, 1959; Giles et al., 1968; Srivastava, 1974; Erikson et al., 1970; Jenkins, 1965; Mitchell et al., 1977; Corcos and Scarborough, 1978). That there is much variation in these reported race/ethnic group frequencies can be seen from data compiled in Table 37 and probably reflects the diversity of sampling techniques used, as well as sample size of the populations tested.

Of the six race/ethnic groups sampled in the present study, only two groups, the White/Caucasians and Black/Afro-Americans had sufficient numbers represented to facilitate comparisons. Using the high concentration of PTC (81.25 mg/l) to distinguish tasters from nontasters, the finding of 21.5 percent nontasters in the White/Caucasian group is in good agreement with previously reported data and the value of 17.7 percent nontasters in the Black population is also well within limits of values derived from earlier studies. It will also be noted that the

Table 37.--Population Frequencies of PTC Nontasters (From Several Sources).

Population	Frequency (%)	Population	Frequency(%)
English	22.9-34.0	Tibetans	10.7-14.0
U.S. Whites	20.0-37.7	Chinese	6.0
Danish	31.8	Formosans	1.8-11.0
Norwegians	17.6-30.5	Japanese	7.0- 9.0
Swedish	32.0	Burmese	12.0
Finnish	10.5-29.7	Central Asians	19.4
Russians	31.4	Koreans	3.0
Brazilian Whites	22.0	Eskimos	25.8-49.0
Jewish (Palestine)	28.0	Indians (N. Amer.)	2.0- 6.0
Jewish (N. Africa)	15.0	Indians (N.&Cen. Amer.)	0.0- 9.1
Armenians	32.0	Muslims (India)	51.6-58.6
Seminites (Palestine)	32.0	Muslims (Bagdad)	29.5
Portuguese	24.0	Bombay Indians	40.0-42.5
Welsh	17.2	Iraqis	16.0
Spanish	24.8	Iranis	25.0
African Blacks	2.3-13.7	Hindus	33.7
U.S. Blacks	8.0-20.0	Arabs (Sudan)	25.4-37.0
Brazilian Blacks	11.6	Arabs (Kenya)	25.4
Ethiopians	3.9-13.9	Arabs (Syria)	36.5
Negritos (Malaya)	18.0	Egyptians	24.0
Malays	15.6	Australian (Natives)	49.0
Aborigines	4.0	Pygmies (New Guinea)	49.2

difference in the nontaster frequencies obtained for these two groups is statistically significant (see Table 14b).

In this study an attempt was made to assess the effects of smoking on PTC perceptions by comparing responses of smokers and nonsmokers. Although no significant association of smoking status and overall perceptions for each PTC concentration was observed, the discovery that smokers consistently were more likely to find each of these solutions tasteless suggests that smoking may produce some effect (Table 17a). The additional finding that differences in the absolute frequencies of tasters and nontasters in these two groups were indeed significant for the low PTC concentration, although not for medium and high concentrations, strongly suggests that smokers may have reduced taste sensitivity and thus have higher PTC thresholds. These results are at variance with some of the previous smoking and PTC studies but are in agreement with others. Falconer (1946) reported no apparent threshold differences between smokers and nonsmokers and Salmon and Blakeslee (1935) found no strong correlations between use of tobacco and PTC sensitivity. Krut et al. (1961) reported a higher but not significant mean threshold in smokers and Fischer et al. (1963) found fewer smokers (especially those who smoked at least fifteen cigarettes per day) among sensitive tasters with the lowest thresholds but the difference was not statistically significant. Hall and Blakeslee (1945) however, concluded that smoking reduces acuity to PTC and Leguebe (1969) as well as Thomas and Cohen (1960) found a significant association between high PTC thresholds and smoking. In spite of the lack of agreement of the effects of smoking on PTC thresholds, it is interesting to note that all of these studies, including the present

one concur that the distribution of tasters and nontasters is similar in smokers and nonsmokers (as assessed by perceptions of 81.25 mg/l), however, in light of all of the above findings, it is also clear that the relationship of smoking and PTC threshold sensitivity deserves further investigation.

Assessments of the effect of time since last food eaten on PTC perceptions made in this study produced unexpected and interesting results. The frequencies of overall taste responses as well as proportions of tasters and nontasters in each elapsed time category were similar for each PTC concentration. However, a significant difference was observed for the bitter versus nonbitter responses for the highest concentration (Tables 20a and 20b). Additional intriguing results were the significantly lower proportion of tasters than nontasters for the high concentration and less bitter than nonbitter responders for the medium and high concentrations when these perceptions were compared, at elapsed times of less than versus greater than one hour (Table 20c). These data suggest a decreased sensitivity to PTC in general and its perception as bitter in particular, during the first hour after the ingestion of food. These findings, reminiscent of those suggested from hunger studies by Yensen (1959) and Gusev (1940) which were mentioned earlier, have not been previously reported for PTC and thus should be worthy of extended study.

Taste Perceptions of Antidesma

The present study has confirmed the diversity of taste responses of Antidesma as initially reported by Henkin and Gillis (1977). These differences in taste responses were found both for Antidesma aqueous

extracts (Ad I) and for liquified Antidesma macerated material (Ad II). While perceptions of this latter solution cannot be strictly compared with the Henkin and Gillis report, it was included in the taste sampling because preliminary results from a small pilot study suggested a less than expected proportion of bitter responders (< 5 percent) for the aqueous extract while an appreciable number of individuals (> 10 percent) who sampled the actual fruit were bitter responders. It was thought that perhaps the major factor(s) responsible for eliciting the bitter response might reside in parts of the fruit other than the aqueous extract.

When overall taste responses to both Antidesma I and II were examined, it was observed that the frequency of misclassification of control solutions had no apparent effect on the perceptions of the Antidesma solutions (see Tables 3a and 3b) thus suggesting that most individuals sampled were able to recognize the basic taste qualities. There was considerable diversity of taste responses for each Antidesma solution ranging from 0.6 percent salty to 50.9 percent sweet for Antidesma I and 0.0 percent tasteless to 45.9 percent sour for Antidesma II. Other perceptions of Ad I were tasteless--0.8 percent, sour--36.0 percent and bitter--11.7 percent and for Ad II, 25.4 percent sweet, 0.5 percent salty and 28.2 percent bitter. Subjects also recorded a greater mean intensity for Ad II than for Ad I (3.098 versus 2.493). When the taste perceptions of Ad I and II were compared, highly significant differences were found for overall responses as well as for dichotomous categories (e.g., bitter-nonbitter, sweet-nonsweet, etc.) of the major perceptions of these solutions (see Tables 24a, 24b and

24c), thereby suggesting major differences in composition of the two Antidesma preparations.

Table 38 compares Antidesma perceptions from the present study and those reported by Henkin and Gillis. It can be observed that while the absolute proportions of responders and nonresponders to aqueous extracts were not identical in both studies, the differences were not significant. Conversely, differences in responses for the Antidesma extract of Henkin and Gillis and those of the Antidesma II (macerated material) of the present study were highly significant ($p < 0.01$). The favorable comparison of responses to the aqueous extracts in both investigations suggests that these two solutions are quite similar and that they are dissimilar to the macerated material (Ad II). These data additionally show that components of the macerated material also strongly elicit bitter perceptions as evidenced by the even greater frequency of bitter responders to Ad II. Whether this represents a concentration effect and/or additional bitter evoking factors is presently unclear but may be elucidated by further research.

As noted earlier, overall perceptions of Antidesma solutions in this study were not strongly associated with age. However, when the bitter-nonbitter (responders-nonresponders) classification was employed, significant differences were observed among the various age groupings, although no definitive age trends could be discerned (Tables 7a and 7b). These findings do not concur with those of Henkin and Gillis who reported no relationship in responsiveness to Antidesma with age. Failure of these workers to note any age effects may have been due to their smaller sample size (170 versus 1,438 subjects)

Table 38.--Comparison of Antidesma Responders and Nonresponders.*

	Henkin & Gillis (H-G) (aqueous extract)		Present Study: Ad I (aqueous extract)		Present Study: Ad II (liquified macerated material)	
	No.	%	No.	%	No.	%
Responders	25	14.7	168	11.7	405	28.2
Nonresponders	145	85.3	1270	88.3	1033	71.8

H-G with Ad I: $\chi_1^2 = 1.315$, $p > 0.05$

H-G with Ad II: $\chi_1^2 = 14.06$, $p < 0.01$

*Responders = Bitter responses

Nonresponders = Nonbitter responses

and/or the greater mean age of subjects (43 years versus 21.9 years). It is probable that this latter factor may be the more contributory one since in the present study, greater deviations in frequencies of responders to Antidesma extract were found for younger age groupings.

The lack of correlations between taste perceptions of Antidesma aqueous extracts and sex of respondent as reported by Henkin and Gillis has been supported by results from the present study. No significant sex differences were observed for overall perceptions for both Antidesma I and II nor for bitter-nonbitter responses for Antidesma I (Tables 10a and 10b). It is interesting to note however, that significant male-female differences were observed in bitter-nonbitter responses to the Ad II macerated material (not included in Henkin-Gillis study). The greater frequency for female bitter responders as well as the general tendency for all subjects to more often judge this solution as bitter when compared to Ad I is suggestive of the increased sensitivity to bitter in females as discussed earlier.

In the current investigation, racial variations in Antidesma taste responses were observed (Tables 13a and 13b). These differences were found to be highly significant especially when bitter and nonbitter responses of Black and White subjects were compared. Bitter responders among Blacks were two to three times more frequent than among whites. These results are in conflict with those of Henkin and Gillis who found no correlation between race or national origin and Antidesma responses. That these researchers were unable to detect race or ethnic diversity for Antidesma perceptions which is so strikingly evident from the present study was probably due to the relative racial homogeneity of their subjects (160 Whites, 8 Blacks and 2 Orientals).

Although not explored in the previous Antidesma investigation, the present work revealed no relationship between smoking status and Antidesma responses (Tables 16a and 16b). Similarly, the time of last food eaten apparently had no appreciable effect (Tables 19a and 19b).

Antidesma Perceptions and PTC Responses

Based on their research, a major conclusion reached by Henkin and Gillis involved the specific association of taste perceptions of Antidesma and PTC since no single individual in their study was a responder (had bitter perceptions) to both of these substances. To examine the validity of this conclusion, taste perceptions of Antidesma I and Antidesma II were compared to responses to three concentrations of PTC. (Different PTC concentrations were used since the exact concentration employed by Henkin and Gillis was not stated in the original report.) No significant differences were observed for any of the specific perceptions of Antidesma I (comparable to extract used in the original study) with respect to any specific taste response to each of the PTC concentrations. Furthermore, the proportions of PTC tasters and nontasters were randomly distributed with respect to specific perceptions of Ad I (Tables 21a, b, and c; 22a, b, and c; and 23a, b, and c). In addition, 91 subjects found both Ad I and the low PTC concentration bitter, 102 responded bitter to Ad I and medium PTC and 111 individuals judged Ad I and PTC high as bitter (Tables 21c, 22c, and 23c). These values represented 6.3 percent, 7.1 percent and 7.7 percent respectively of the total population sampled and therefore, are not in agreement with the original report. When Antidesma II (macerated material) and PTC perceptions were compared, discordant results were obtained. While

comparisons of Ad II perceptions with respect to overall responses to each PTC concentration were similar, these Ad II perceptions were significantly different when compared to PTC bitter-nonbitter responses at each concentration (Tables 21b, 22b, and 23b). A similar significant difference was seen when Ad II bitter-nonbitter groupings were also compared to the bitter-nonbitter dichotomy for each concentration of PTC (Tables 21c, 22c, and 23c). While results obtained utilizing the macerated material cannot be directly related to the Henkin and Gillis data, because the significant differences observed were mainly due to the less than expected frequencies of individuals who judged both Ad II and PTC as bitter, this does suggest that some relationship of bitter cognition for these two substances may exist although not as strict as proposed by the original study.

The above findings pose an interesting problem. It is not evident why the results obtained from the macerated material of Ad II suggest a possible, although limited relationship to that of the Henkin-Gillis data while those obtained with the aqueous extract (Ad I) fail to provide evidence in support of their data. Possible explanations may involve concentration differences for both the Antidesma and PTC solutions and/or variations in sampling techniques as alluded to earlier. In spite of potential reasons for discrepancies with the previous report, overall results from the present study clearly do not support the mutual exclusivity of bitter perceptions of Antidesma and PTC as observed by Henkin and Gillis.

Family Studies of Taste Perceptions

The majority of taste perception data in families was derived from analysis of the 112 two generation families sampled. These results showed that offspring had slightly greater but insignificant misclassification rates for control solutions when compared to parents. Offspring on the average also recorded higher intensities for each of the controls than their parents (Tables 25a and 25b). This may be suggestive of some possible age effect. Additional variation between these two groups was seen in their overall taste responses to Antidesma I where significant differences between parents and offspring were observed. Whether these findings are due to judgemental differences or real sensory variations is unclear. However, no such variation was found for progeny versus parental perceptions for Antidesma II nor for any of the PTC concentrations (Tables 26a, 26b, 27a, and 27b).

Genetic Analysis of PTC and Antidesma Taste Perceptions

Statistical analysis by Chi-square of the offspring resulting from the various mating types with respect to PTC taster-nontaster phenotypes revealed highly significant differences between observed and expected progeny thus implying that these results were not likely to be due to chance alone. When these data were subsequently analyzed for their concordance with the genetic hypothesis, that PTC tasting is dominant and nontasting is recessive, it was found that they were in excellent agreement ($p > 0.95$) with this well established theory (Table 28). This close agreement was further substantiated by the three generation PTC family data in which no exceptions to this hypothesis were observed (Fig. 5, families 59, 62 and 63).

When similar statistical treatment was performed for the dichotomous classifications (e.g., bitter versus nonbitter, sour versus nonsour, etc.) of the two Antidesma solutions, with the assumption that the basic taste perceptions were recessive, divergent findings were observed. With respect to Antidesma I, tests for randomness for observed and expected frequencies of offspring resulting from the various matings disclosed that only the bitter-nonbitter perceptions appeared to be nonrandom, while the sweet-nonsweet and sour-nonsour perceptions could be accounted for by chance ($p > 0.05$) (see Tables 29, 30 and 31). Upon subsequent testing of the proposed genetic hypothesis for these perceptions, it was found that there was support for a dominant-recessive mode of inheritance for the bitter versus nonbitter perceptions ($0.5 < p > 0.1$) while this hypothesis was rejected with a high degree of confidence for the other taste perceptions ($p < 0.05$). Somewhat different results were obtained from analysis of the Antidesma II two-generation family data (Tables 32, 33 and 34). Although the major taste perceptions of this solution appeared unlikely due to chance ($p < 0.05$), the overall evidence strongly supported rejection of a dominant-recessive pattern of inheritance since the probability that these data conformed to this proposed hypothesis were all less than 0.02.

Taste perception data for Antidesma I and II from the three generation families were ambiguous in that there was support for previously rejected recessive hypotheses for sweet and sour perceptions of Antidesma I but lack of support for possible recessive nature of the bitter perception accepted earlier. Likewise, Antidesma II taste perception patterns observed in these families in one instance

supported the absence of dominant-recessive inheritance for the bitter perception while in another case the reverse was seen. Due to the small numbers of these families and the absence of results for several first generation members, definitive conclusions were unwarranted.

From the foregoing discussion, it may be noted that based on evidence from the majority of the families studied, a dominant-recessive hypothesis was primarily supported only in the case of bitter-nonbitter responses for Antidesma I. It is not clear why these same responses obtained for Antidesma II did not produce similar results. It may be that additional bitter evoking factors in this second solution were unrelated to those in Antidesma I. On the other hand, if these bitter response-causing agents are similar in both solutions, it may be that Antidesma II contained a much greater concentration of these, producing results which obscured genetic tendencies in favor of the tested hypotheses. If such is the case, these results would be somewhat analogous to those obtained in some PTC studies when tasters and nontasters are identified by use of concentrations which are much higher than the population antimode (> 81.25 mg/l). The additional probability of nonrandomness observed for each major perception of Antidesma II was also enigmatic. Whether this represents specific intervening environmental or other genetic factors was not obvious from this investigation.

Taste Perceptions of Twins

Analysis of taste perception data for the twelve pairs of twins in this study produced uniform results. No significant differences were observed between the monozygous and dizygous twins for each of the PTC concentrations and for the two Antidesma preparations (Table 35).

Similarly, when concordance rates for these two types of twins were examined, no significant differences for overall PTC and Antidesma responses, for bitter versus nonbitter perceptions nor for PTC taster-nontaster frequencies (Tables 36a and 36b). These data suggest a lack of strong genetic influence on taste perceptions of these substances and appear to be at variance with a previous report. Although there are no prior studies of Antidesma perceptions in twins, Martin (1975) from an investigation of PTC tasting in twenty-eight MZ and eighteen DZ twin pairs reported a significant variance in concordance thresholds between the two twin groups. These findings may not be strictly comparable with those of the present study since in the previous investigation, thresholds were assessed by use of fourteen different concentrations of PTC, there was serological determination of twin zygosity and a much larger population of twins was sampled. Definitive conclusions from the present study may therefore be severely limited. It is interesting to note however, that calculations of the probabilities of similarity of concordance rates for MZ versus DZ twins produced higher probabilities ($p = 0.318$-1.0) for the PTC data than for the Antidesma results ($p = 0.221$-0.530). Since differences in PTC perception are known to be genetically determined, the greater similarity between MZ and DZ twin concordance rates for PTC than for Antidesma may suggest that genetic influences on Antidesma perceptions should not be ruled out. However, definitive conclusions are unwarranted due to the small sample size of twins studied.

Summary

The principal purposes of this study, prompted by the previously reported association between taste perceptions of PTC and

extracts from the fruit of Antidesma bunius, were to assess taste responses for these substances by age, sex and racial groupings, to study associations between PTC and Antidesma taste responses, to determine from family studies if taste perceptions of Antidesma could be accounted for by a simple dominant-recessive genetic hypothesis and to ascertain if additional factors such as smoking status and time of last food eaten have effects on these taste perceptions. The additional use of solutions as controls for the various taste qualities also allowed estimates of the reliability of taste perceptions recorded, as well as quantification of misperceptions of substances typically perceived in a certain manner by a majority of human subjects. Towards these ends, taste responses to standard control solutions, three concentrations of PTC and two preparations of Antidesma were assessed for 1,438 subjects which included unrelated individuals and family groupings. A summary of the major findings from this study are listed below.

1. Misclassification rates of 1.4 percent to 17.9 percent for control solutions for the taste qualities of sweet, tasteless, salty, sour and bitter were found to be much less than those reported from previous studies, although in general agreement with other reports, the greatest tendency for misclassification occurred in the distinction between bitter and sour. Perceptual errors in controls did not appear to be significantly affected by race, age, sex, smoking status nor elapsed time since last food eaten. Additionally, misidentifications of controls did not appear to produce significant differences in taste responses to PTC and Antidesma.

2. The majority of subjects sampled judged each of the PTC solutions as bitter or tasteless as expected, however, other perceptions ranging from 0.09 percent for sweet to 4.9 percent for sour were also reported. Based on responses to the PTC solution concentration of 81.25 mg/liter, the overall incidence of tasters was 75.8 percent and of nontasters, 24.2 percent. Corresponding bitter-nonbitter responses at this concentration were 70.1 percent and 29.9 percent respectively.

3. Analysis of PTC perceptions by age groupings of subjects who ranged from ages seven to seventy-two showed no significant age effects on overall perceptions, taster-nontaster frequencies nor bitter-nonbitter responses.

4. Comparison of PTC perceptions for the 620 males and 818 females revealed no significant sex differences for overall perceptions nor taster-nontaster frequencies. The slightly greater proportion of female tasters at each concentration level and the significantly higher frequency of female bitter responders for the low PTC concentration suggests that females may have greater taste sensitivity to this substance.

5. The frequencies of nontasters in the 1,213 White/Caucasians and the 198 Black/Afro-Americans were 21.5 percent and 17.7 percent respectively. These differential racial frequencies were found to be statistically significant and were in good agreement with values reported from previous studies.

6. No significant associations of smoking status and overall PTC perceptions were found when responses of 258 smokers and 1,180 nonsmokers were compared, however, smokers were consistently more likely to describe each PTC concentration as tasteless and the

proportion of nontasters among smokers was significantly higher than that of nonsmokers for the low PTC concentration. This suggests that smoking may reduce PTC taste acuity.

7. Elapsed time since last food eaten appeared to have a significant effect on PTC perception especially in the case of bitter responses. This effect seems most pronounced within the first hour after food ingestion and was evidenced by a significantly lower proportion of tasters of the high PTC concentration and less bitter responders for the medium and high concentrations.

8. Comparisons of taste perceptions of the two Antidesma preparations used (aqueous extract and liquified macerated material) revealed significant differences in overall responses as well as for dichotomous classifications of the major perceptions of these solutions which is suggestive of inherent compositional differences.

9. No significant effects of age on the overall perceptions of the two Antidesma solutions were observed however significant differences among age groupings were found when perceptions were classified by the bitter-nonbitter dichotomy although no specific age trends could be discerned.

10. When compared to males, a significantly greater proportion of females were bitter responders for Antidesma II (macerated material). No other significant sex differences were observed for either the overall perceptions of both Antidesma I and II or bitter-nonbitter responses for Antidesma I (aqueous extract).

11. Highly significant racial differences between Blacks and Whites were found for Antidesma bitter-nonbitter responses.

12. No apparent effects of smoking on Antidesma perceptions were evident. Likewise, elapsed time since last food eaten produced no absolute effects.

13. There were no significant associations observed for any specific taste perceptions of Antidesma I with any taste response to each of the PTC concentrations. Frequencies of PTC tasters and nontasters were also randomly distributed with respect to Antidesma I perceptions. Conversely, overall perceptions as well as bitter-nonbitter perceptions of Antidesma II showed significant correlations with PTC responses primarily due to the less than expected frequency of individuals who judged both Antidesma II and PTC as bitter. There was however, no mutual exclusivity of bitter perceptions for either Antidesma II or I and PTC.

14. Analysis of PTC taster-nontaster progeny frequencies from various mating types showed close agreement with the generally established dominant-recessive hypothesis. Support for this hypothesis for the Antidesma taste perceptions in families was found only in the case of bitter-nonbitter responses for Antidesma I.

15. Comparisons of twin concordance rates for Antidesma perceptions revealed no significant differences between concordance of MZ and DZ twins. The probabilities of similarity of concordance rates for MZ versus DZ twins was higher for the PTC than for the Antidesma results.

APPENDICES

APPENDIX A

DERIVATION OF SNYDER'S RATIOS

APPENDIX A

DERIVATION OF SNYDER'S RATIOS

Frequencies of Mating Types and Offspring

Mating Types	Frequency	Offspring		
		TT	Tt	tt
TT x TT	p^4	p^4		
TT x Tt	$4p^3q$	$2p^3$	$2p^3q$	
TT x tt	$2p^2q^2$		$2p^2q^2$	
Tt x Tt	$4p^2q^2$	p^2q^2	$2p^2q^2$	p^2q^2
Tt x tt	$4pq^3$		$2pq^3$	$2pq^3$
tt x tt	q^4			q^4

Percent Recessives from Dominant x Recessive Matings (one parent = dominant) = S_1: (TT x tt and Tt x tt Matings)

Dominant Progeny = $2p^2q^2 + 2pq^3 = 2pq^2$

Recessive Progeny = $2pq^3$

so that:

$$S_1 = \frac{R}{D + R} = \frac{2pq^3}{2p^2q^2 + 4pq^3} = \frac{2pq^3}{2pq^2\,(p + 2pq)} = \frac{q}{p + 2q} = \frac{q}{1 + 9}$$

Percent Recessives from Dominant x Dominant Matings (both parents = dominant) = S_2: (TT x TT, Tt x TT, Tt x Tt Matings)

Dominant Progeny = $p^4 + 2p^3q + 2p^2q^2 = p^2(L + 2q)$

Recessive Progency = p^2q^2

so that:

$$S_2 = \frac{R}{D + R} = \frac{p^2q^2}{[p^2(1 + 2q) + (p^2q^2)]} = \frac{q^2}{(1 + q)^2}$$

APPENDIX B

COMPARISON OF PTC AND ANTIDESMA RESPONDERS AND NONRESPONDERS (HENKIN AND GILLIS, 1977)

APPENDIX B

COMPARISON OF PTC AND ANTIDESMA RESPONDERS AND NONRESPONDERS (HENKIN AND GILLIS, 1977)

	Responders	Nonresponders
PTC		
Subjects	115	55
Sex	57 males; 69 females	31 males; 22 females
Mean Age (yrs., range)	44 (9-78)	41 (7-89)
Mean Response Intensity (%, range)	81.6 (5-100)	1.5 (0-30)
Median Response Intensity (%)	100	0
Median Response Quality (Response, No.)	Bitter (115)	Tasteless (47)
Mean Response Frequency (%)	67.6	32.4
Antidesma		
Subjects	25	145
Sex	16 males, 9 females	71 males; 83 females
Mean Age (yrs., range)	43 (7-89)	42 (9-78)
Mean Response Intensity (%, range)	39 (5-100)	24 (0-100)
Median Response Intensity (%)	20	12
Median Response Quality (Response, No.)	Bitter (25)	Sour (67)
Mean Response Frequency (%)	14.7	85.3

	Antidesma Responders	Antidesma Nonresponders
PTC Responders	0	115
PTC Nonresponders	25	30

APPENDIX C

LETTERS OF INTRODUCTION TO HOUSEHOLDS

MICHIGAN STATE UNIVERSITY

DEPARTMENT OF ZOOLOGY · NATURAL SCIENCE BUILDING EAST LANSING · MICHIGAN · 48824

November 27, 1979

Dear Tamarisk Resident:

Have you ever wondered why you like certain foods while other people you know find these same foods distasteful? For example, have you ever thought about why one person may like ketchup and relish on a hotdog while another person will eat only hotdogs with mustard and onions?

If you were to take an opinion poll of different groups of people to determine how many liked foods such as strawberries, asparagus, liver, tomatoes, spinach or other common foods, you would discover a great variety of responses with respect to food preferences among the individuals of the different groups. As you probably know, such diversity of taste responses may be related to a number of factors such as the type of foods we eat most frequently or those foods which we have been influenced to like or dislike during our earlier years. What you may not know is that our perceptions of certain foods may be determined or strongly influenced by genetic factors--those same kind of factors which we have inherited from our parents that determine our blood type, eye color, height or other characteristics.

Because the role of genetic factors in determining our differences in taste responses is not well understood, we are currently conducting a study of the genetics of taste perceptions and would be very grateful if you and your family would consent to be a part of this study. Your participation would involve the tasting of a few drops of several solutions, recording your taste perceptions and recording a few items of demographic importance such as age, sex, time of last food eaten, etc. This procedure will only require about ten minutes per family member and has no greater risk than the tasting of common food substances.

During the next few weeks a member of our team will be contacting you to schedule a convenient time for your family should you decide to participate in this study and answer any questions you may have regarding the project.

We sincerely hope that you will consent to participate in this study which will help us learn more about those factors which determine individual taste preferences and responsiveness to certain foods.

Respectfully yours,

Frankie J. Brown
Graduate Student

James V. Higgins, Ph.D.
Professor

MICHIGAN STATE UNIVERSITY

DEPARTMENT OF ZOOLOGY · NATURAL SCIENCE BUILDING EAST LANSING · MICHIGAN · 48824

Winter, 1980

Dear Tamarisk Resident:

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Because the role of genetic factors in determining our differences in taste responses is not well understood, we are currently conducting a study of the genetics of taste perceptions and would be very grateful if you and your family would consent to be a part of this study. Your participation would involve the tasting of a few drops of several solutions, recording your taste perceptions and recording a few items of demographic importance such as age, sex, time of last food eaten, etc. This procedure, which can be done in your home, will only require about ten minutes per family member and has no greater risk than the tasting of common food substances.

During the next few weeks a member of our team will be contacting you to schedule a convenient time for your family should you decide to participate in this study and answer any questions you may have regarding the project. If you prefer, you may complete and return the enclosed form as soon as possible to indicate your interest. (Please note: Because this is a genetic study, we are in need of families in which both mother and father are present in the household along with at least one child of age 7 or older, not including adopted children or children by previous marriages).

We sincerely hope that you will consent to participate in this study which will help us learn more about those factors which determine individual taste preferences and responsiveness to certain food.

Respectfully yours,

Frankie J. Brown
Graduate Student
Telephone: 355-4600

James V. Higgins, Ph.D.
Professor
Telephone: 353-2030

GENETICS OF TASTE PERCEPTION STUDY

Please check appropriate responses below:

_____ We will participate in the Taste Perception Study.

_____ We may participate in the Taste Perception Study but have additional questions.

_____ We do not wish to participate in the Taste Perception Study for the following reason(s): _____

_____

Name_____ Telephone_____

Address_____

Total number of non-adopted children in family _____

Number of non-adopted children of age seven or older _____

Best time to schedule our family: Weekday evenings ____ Weekends _____

(Please note: While we do hope that you will consent to participate in this study, it is important for accounting purposes that we hear from you even if you do not wish to volunteer. We would be most grateful if you would complete and return this form in the envelope provided at your earliest convenience. Thanks in advance for your cooperation.)

APPENDIX D

CONSENT FORM AND SURVEY QUESTIONNAIRE

APPENDIX D

INFORMATION AND CONSENT FORM FOR PARTICIPANTS IN THE STUDY ENTITLED GENETIC STUDIES OF TASTE PERCEPTION OF ANTIDESMA AND PHENYLTHIOCARBAMIDE

The study in which you are asked to participate may have future usefulness but at present is not essential to the diagnosis nor treatment of any known medical condition. It is a research study in which the differences in taste perceptions of Antidesma and Phenylthiocarbamide will be investigated. Antidesma is a fruit from which pies, jams, and jellies are made and Phenylthiocarbamide is a substance often used in genetic studies of tasting. The purpose of this study is to gather information which may be useful for the improvement of our understanding of the inheritance of taste perceptions of these substances in human populations.

It is important that you understand that no direct benefits to you are guaranteed by your participation in this study and that your responses will be kept confidential and that if published will be stated in such a way that anonymity will be preserved. You should also understand that the only acts required of you in this study are the taste sampling of certain solutions (antidesma, phenylthiocarbamide, quinine, fruit juices, and other common solutions) which should be of no greater hazard to you than the tasting of common food substances and the completion of a questionnaire to record your responses and other information of demographic importance. You should further understand that you are free to discontinue your participation in this study at any time should you elect to do so.

Statement of Consent

The study entitled Genetic Studies of Taste Perception of Antidesma and Phenylthiocarbamide has been explained to me, and I understand the purpose, requirements and risks of my participation and freely consent to participate.

I understand that in the unlikely event of physical injury resulting from research procedures, Michigan State University, its agents, and employees will assume that responsibility as required by law. Emergency medical treatment for injuries or illness is available where the injury or illness is incurred in the course of an experiment. I have been advised that I should look toward my own health insurance program for payment of said medical expenses.

Signature_____ Date_____

If a minor (under age 18), parent or guardian must sign and state relationship. _____

Questionnaire to be completed by Participants in the Investigation Entitled Genetic Studies of Taste Perceptions of Antidesma and Phenylthiocarbamide

1. Name_____ 2. Date and Time of Test_____

3. Address_____ 4. Phone Number_____

5. Student Number (if student)_____

6. Age_____ 7. Sex (Circle One) Male Female

8. Race/Ethnic Group (Circle One) White/Caucasian, Black/Afro-American, Chicano/Mexican American, Spanish American/Hispanic, American Indian, Asian/Pacific Islander

9. Time of last food eaten_____ 10. Smoker or Non-Smoker (Circle One)

11. Taste Responses:
Circle the term below which best describes the taste of the solutions listed then rate the intensity of that taste on a scale of 1-5 where #1 is mildest and #5 is strongest. (Example: If the solution tastes slightly salty, you would circle salty and the #1 next to the word salty). If the solution has no taste, circle the word tasteless.
In each case where you can detect a specific taste, please complete the sentence following each solution to describe what that solution tastes most like from your previous taste experiences.

Please be sure to eat an unsalted cracker and rinse your mouth after tasting each solution.

Solution A is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution A tastes like_____

Solution B is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution B tastes like_____

Solution C is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution C tastes like_____

Solution D is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution D tastes like_____

OVER

Solution E is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution E tastes like_____

Solution F is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution F tastes like_____

Solution G is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution G tastes like_____

Solution H is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution H tastes like_____

Solution I is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution I tastes like_____

Solution J is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution J tastes like_____

Solution K is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution K tastes like_____

Solution L is:

Tasteless

	Mild →				Strong
Salty	1	2	3	4	5
Bitter	1	2	3	4	5
Sweet	1	2	3	4	5
Sour	1	2	3	4	5

Solution L tastes like_____

APPENDIX E

RATIONALE FOR USE OF DIFFERENT STATISTICS EMPLOYED

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RATIONALE FOR USE OF DIFFERENT STATISTICS EMPLOYED

Data included in this dissertation have been analyzed by use of several statistics. For simple frequency data, ranges, means, medians and modes have been calculated where applicable. For comparisons of one variable with another (crosstabulations), four statistical tests were employed to determine if associations existed between the variables. The tests used were the Chi-square, Cramer's V, Lambda Asymmetric, Lambda Symmetric and Z transformation statistics. These statistics were selected because they are more suitable when variables in cross-tabulation tables are measured at the "nominal" level, that is, variable values represent a distinct category and the value itself serves merely as a label or name for the category (e.g., sweet, bitter, White/ Caucasian, male, female, etc.). Unlike ordinal-level and interval-level measurements, with nominal-level variables, no assumptions of ordering or distances between the categories are made. For analysis of family data and tests of genetic hypotheses, the Z-transformation and Fisher's exact probability test statistics were used. A brief description of each type of analysis used follows.

Chi Square

The Chi-square test of statistical significance, used to determine whether a systematic relationship exists between two variables is usually most appropriate when at least one of the variables can be placed into dichotomized categories (e.g., taster versus nontaster, bitter versus nonbitter, etc.), although in some instances this analysis is used when more than two categories for each variable are present. In crosstabulation tables, Chi-square is calculated by computing the cell frequencies which would be expected if no relationship is present between the variables given the existing row and column totals. The expected cell frequencies are then compared to the actual values found in the table according to the following formula:

$$\chi^2 = \sum_i \frac{\left(f_o^i - f_e^i\right)^2}{f_e^i}$$

where f_o^i equals the observed frequency in each cell, and f_e^i equals the expected frequency calculated as

$$f_e^i = \left(\frac{c_i r_i}{N}\right)$$

where c_i is the frequency in a respective column marginal, r_i is the frequency in a respective row marginal and N stands for the total number of valid cases. The greater the discrepancies between the expected and actual frequencies, the larger chi-square becomes.

If no relationship exists between two variables in the sample under study, then any deviations from the expected values which occur

in a table based on randomly selected sample data are due to chance. While some small deviations can be reasonably expected due to chance, large deviations, i.e., large values of chi-square, are unlikely. Since we do not know what the actual relationship is in the universe, we interpret small values of chi-square to indicate the absence of a relationship, often referred to as statistical independence. Conversely, a large chi-square implies that a systematic relationship exists between the variables. In order to determine whether a systematic relationship does exist, it is necessary to ascertain the probability of obtaining a value of chi-square as large or larger than one calculated from the sample, when in fact the variables are actually independent. This depends, in part, upon the degrees of freedom. The degrees of freedom vary with the number of rows and columns in the table, and they are important because the probability of obtaining a specific chi-square value depends on the number of cells in the table.

By itself, chi-square helps us only to decide whether our variables are independent or related. It does not tell us how strongly they are related. Part of the reason is that the sample size and table size have such an influence upon chi-square. Several statistics which adjust for these factors are available. When chi-square is thus adjusted it becomes the basis for assessing strength of relationship.

Phi*

For a 2 x 2 table, the phi statistic is a suitable measure of association, i.e., a measure of strength of relationship. Phi (ϕ) makes

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*This statistic is not used directly but its explanation is included here because the Cramer's V which is used is a modified version of Phi.

a correction for the fact that the value of chi-square is directly proportional to the number of cases N by adjusting the X^2 value. Its formula is:

$$\phi = \left(\frac{\chi^2}{N}\right)^{\frac{1}{2}}$$

Phi takes on the value of 0 when no relationship exists, and the value of +1 when the variables are perfectly related, i.e., all cases fall just on the main or the minor diagonal.

Cramer's V

Cramer's V is a slightly modified version of phi which is suitable for larger tables. When phi is calculated for a table which is not 2 x 2, it has no upper limit. Therefore, Cramer's V is used to adjust phi for either the number of rows or the number of columns in the table, depending on which of the two is smaller. Its formula is:

$$V = \left(\frac{\phi^2}{\min\ (r-1,\ c-1)}\right)^{\frac{1}{2}}$$

V also ranges from 0 to +1 when several nominal categories are involved. Thus, a large value of V merely signifies that a high degree of association exists, without revealing the manner in which the variables are associated.

Lambda

Lambda is a measure of association for crosstabulations based on nominal-level variables.

Asymmetric lambda measures the percentage of improvement in our ability to predict the value of the dependent variable once we know the value of the independent variable. This is based on the assumption that the best strategy for prediction is to select the category with most cases (modal category), since this will minimize the number of wrong guesses. All the remaining measures of association are based on this concept, which is called proportional reduction in error. The formula for asymmetric lambda is:

$$\text{Lambda} = \lambda_{\text{assym.}} = \frac{\sum_{k} \text{max. } f_{jk} - \text{max. } f._{k}}{N - \text{max. } f._{k}}$$

where $\sum_{k} \text{max. } f_{jk}$ represents the sum of the maximum values of the cell frequencies in each column, and max. $f._{k}$ represents the maximum value of the row totals.

The maximum value of lambda is 1.0, which occurs when prediction can be made without error, i.e., when each independent variable category is associated with a single category on the dependent variable. A value of zero means no improvement in predicting.

Asymmetric lambda is computed for each of the variables. The two results are likely to be different since the one-way (marginal) distributions are not usually the same. A symmetric lambda is also computed, which is a kind of average of the two asymmetric values. It makes no assumptions about which variable is dependent and it measures the overall improvement when prediction is done in both directions. Its formula is:

$$\text{Lambda} = \lambda_{symm} = \frac{\sum_{k} \max. f_{jk} + \sum_{j} \max. f_{jk} - \max. f._{k} - \max. f_{j}}{2N - \max. f._{k} - \max. f_{j}}$$

where $\sum_{k} \max. f_{jk}$ and $\max. f._{k}$ are as defined for lambda asymmetric, $\max. f_{j}$ is the maximum column total, and $\sum \max. f_{jk}$ is the sum of the maximum values of the cell frequencies in each row (Nie et al., 1975).

Z-transformations (Transformation to Standard Normal Distribution)

For testing dominant-recessive hypotheses by use of Snyder's ratio, Z-transformations are more appropriate since Snyder's ratios calculate the expected proportions of offspring from the various matings. Chi-square analyses are less applicable here since the differences between two proportions are compared and because in some instances the expected proportion of certain types of offspring is zero. For example, for the hypothesis that the inability to taste PTC is recessive, the expected proportion of offspring with the dominant taster phenotype from nontaster x nontaster matings is zero. If Chi-square analysis is used data from this mating combination cannot be tested. Furthermore, Chi-square analysis requires use of whole numbers rather than proportions. The Z transformation however, can be used to test the difference between two proportions as well as allow the use of data from all mating types in acceptance or rejection of the hypotheses under consideration and is computed as follows:

$$Z = \frac{\text{Obs.} - \text{Exp.}}{\sqrt{\frac{\text{obs.}\ (1\text{-obs.})}{N}}}$$

where Obs. = observed proportion of offspring of a given type from a particular mating

Exp. = expected proportion of offspring of a given type from a particular mating

N = total number of offspring from the particular mating.

Probabilities of Z values thus obtained are then determined from Cumulative Standard Normal Distribution Function Tables in the form of F(Z). If Z values are positive then $1 - F(Z) = \alpha/2$. For negative Z values, $F(Z) = \alpha/2$. From the $\alpha/2$ results, α can be calculated and used in testing hypotheses since the Confidence in rejecting the hypothesis $= 1 - \alpha$.

When the proceeding computations are performed testing results obtained from each of the mating combinations, the total weight of the evidence for acceptance or rejection of the hypothesis can be combined by converting the α values to Chi-square by the following formula: $X^2 = -2 [\Sigma \log_e \alpha]$, where -2 = constant and $\log_e \alpha$ = natural logarithm of α values obtained. Note in this case, there are two degrees of freedom per α included (Gill, 1980).

Fisher's Exact Probability Test

For analysis of concordance rates of taste perceptions of twins, this test was used instead of the Chi-square statistic because of the limited sample size involved. The Chi-square probability distribution is appropriate as the sampling distribution of the X^2 statistic only if the sample size is sufficiently large. A rough guideline for this requirement is as follows: For 2 x 2 contingency tables, the expected frequency f_e^i should be at least five in each cell. The Fisher Exact Probability Test is an extremely useful nonparametric technique for

analyzing discrete data (either nominal or ordinal) when testing differences between two groups involving small sample sizes. Furthermore, it is used when the scores from the two groups fall into one or the other of two mutually exclusive classes, i.e., every subject in both group obtains one of two possible scores. The scores are represented by frequencies in a 2 x 2 contingency table as follows:

	-	+	Total
Group I	A	B	A + B
Group II	C	D	C + D
Total	A + C	B + D	N

Groups I and II might be any independent groups (in analyses performed in this study they represent monozygous and dizygous twin groups). The column headings, here arbitrarily indicated as plus and minus, may be any two classifications (e.g., tasters and nontasters). The test determines whether the two groups differ in the proportion with which they fall into the two classifications. For data in the table above (where A, B, C, and D stand for frequencies), it would determine whether Group I and Group II differ significantly in the proportion of plusses and minuses attributed to them. The exact probability of observing a particular set of frequencies in the 2 x 2 table is given by the formula:

$$P = \frac{(A + B)\,!\,(C + D)\,!\,(A + C)\,!\,(B + D)\,!}{N\,!\,A\,!\,B\,!\,C\,!\,D\,!}$$

That is, the exact probability of the observed occurrence is found by taking the ratio of the product of the factorials of the four marginal

totals to the product of the cell frequencies multiplied by N factorial (Siegel, 1956). When computed, significance levels are determined by choice of α values similar to those used for the Chi-square statistic (e.g., $\alpha = 0.05$).

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