A COMPARISON OF ROASTED PEANUT FLAVOR ATTRIBUTES OVER TIME FOR THREE PEANUT CULTIVARS WITH DIVERS OLEIC: LINOLEIC ACID RATIOS

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I dedicate this thesis to a very special lady, my "Grandma DD" who always supported me in every endeavor with love, encouragement and timely gems of wisdom. I sincerely regret that she did not live to see the fulfillment of the dream that she inspired.

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NOMENCLATURE

Astringency .... chemical feeling on the tongue and in the mouth described as puckering / dry, associated with tannins, as in strong tea (Johnsen, 1986).

Bitter .... taste associated with caffeine or quinine (Johnsen, 1986).

Blanch .... peel the tough, tight-fitting skin from a nut (Lawler, 1961).

Cardboard .... aromatic associated with somewhat oxidized fats and oils and reminiscent of cardboard (Johnsen, 1986).

Dark roasted peanut...... aromatic associated with darkly roasted peanuts, very browned or toasted character (Johnsen, 1986).

Earthy .... aromatic associated with wet dirt and mulch (Johnsen, 1986).

Fatty acid .... long chain monocarboxylic acids having 12-24 carbon atoms. Saturated fatty acids can be represented by the general formula CH3(CH2)nCOOH, with each carbon bonded to the maximum number of hydrogen atoms. Unsaturated fatty acids can be represented by the formula CH3(CH2)nCH=CH(CH2)n'COOH, with each at least one carbon-to-carbon double bond, resulting in carbons which are not "saturated" with hydrogen atoms (Caret, R.L., Denniston, K.J., and Topping, J.J., 1993).

Fishy .... aromatic associated with cod liver oil or old fish (Johnsen, 1986).

Green .... aromatic associated with uncooked vegetables, grass or twigs (Johnsen, 1986).

Hexanal .... an aldehyde, CH3(CH2)4CHO (Caret et al., 1993).

Legumey .... "beany" aromatic associated with raw legumes and beans (Civille, G.V. and Lyon, B.G., 1996.).

Linoleic acid .... a polyunsaturated fatty acid, C17H31COOH, having two double bonds; cis,cis, 9,12-Octadecadienoic acid (Caret et al., 1993).

Mouth coat .... chemical feeling in the mouth described as a film coating on the inside of the mouth (Johnsen, 1986).

Oleic acid .... a monounsaturated fatty acid, C17H33COOH, having one double bond; cis-9-Octadecadienoic (Caret et al., 1993).

Painty .... aromatic associated with linseed oil/oil based paint (Johnsen, 1986).

PPM .... parts per million

Roasted peanutty .... aromatic associated with medium-roasted peanuts (Johnsen, 1986).

Raw bean / peanut .... aromatic associated with lightly roasted peanuts, having legume-like character (Johnsen, 1986).

Salt .... taste associated with table salt (Johnsen, 1986).

Skunky .... aromatic associated with sulfur compounds, which exhibit skunklike or rubberlike character (Johnsen, 1986).

Sour .... taste associated with acids (citric acid) (Johnsen, 1986).

Sweet .... taste associated with sugars (Johnsen, 1986).

Sweet aromatic............. aromatic associated with sweet materials, such as caramel, vanilla, molasses or fruit (Johnsen, 1986).

Woody .... aromatic associated with base peanut character (absence of fragrant top notes) and related to dry wood, peanut hulls and skins (Johnsen, 1986).

CHAPTER I

A COMPARISON OF ROASTED PEANUT FLAVOR ATTRIBUTES OVER TIME FOR THREE PEANUT CULTIVARS WITH DIVERS OLEIC: LINOLEIC ACID RATIOS

Roasting converts the most obvious flavors of a peanut seed from green, legumey, moderately sweet, and "beany" in the raw form to a widely recognized and characteristic roasted nutty flavor. That characteristic roasted nutty flavor of each peanut seed is actually comprised of a variety of tastes, aromatic volatiles, and chemical feeling factors in a unique combination. While the overall first impression of roasted peanut flavor appears to be consistent from one type of peanut to another, sensory panelists trained to identify and quantify intensities of various flavor attributes recognize that there are unmistakable differences in peanut flavors. As time between the initial roasting and tasting increases, the disparity in some of the flavor attributes increases, enabling almost everyone to detect differences in taste between "fresh" and "stale" peanuts. Efforts to extend the time that elapses between roasting and the onset of readily noticeable "off-flavors" indicative of staling and rancidity continue to be on the cutting edge of peanut research (Braddock et al., 1995; Pattee and Knauft, 1995; Pattee and Giesbrecht, 1990).

While there are a variety of factors that can be directly involved in the onset of peanut staling, one primary cause of staling and rancidity in peanuts is the autoxidation of the fatty acids which comprise 45 - 50% of each peanut. Unsaturated fatty acids comprise 80% of all of the fatty acids in peanuts, and oxidative rancidity increases as the levels of polyunsaturated fatty acids increase (Divino et al., 1996). Up to 12 fatty acids have been identified in different peanut oils, but the oleic acid (18:1) and linoleic acid (18:2) proportions constitute 80% of the fatty acids in peanuts (Moore and Knauft, 1989). These unsaturated fatty acids oxidize readily due to their lack of saturation; the greater the degree of unsaturation, the faster oxidation can take place. Linoleic acid oxidizes 64 times faster than oleic acid (Hamilton, 1983). Increasing the degree of saturation of the fatty acids by increasing the ratio of oleic acid to linoleic acid in the peanut oil decreases the rate of oxidation and increases flavor stability over time (Moore and Knauft, 1989). Genetic experiments with Florida Sunrunner peanuts (Sunrunner) produced the Florida SunOleic 95R peanuts (SunOleic) with high oleic: linoleic acid ratios. Similar experiments in crossbreeding are currently in progress with varieties of Oklahoma Spanish peanuts.

With modification of fatty acid ratios, flavor changes may occur in peanuts because the lipid fraction and the fatty acid distribution are responsible for a variety of flavor and character notes, such as aroma, color, texture, flavor and mouthfeel, which combine to make foods acceptable and desirable (St. Angelo, 1996). Identification and comparison both of flavor attributes and of changes in those flavor attributes over time for peanuts with differing oleic: linoleic acid ratios provide indices for flavor modifications and shelf life stability (Braddock et al., 1995).

Purpose and Objectives

The purposes of this study were to:

1.) Compare intensities of roasted peanut descriptors for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting by sensory evaluation of the roasted peanuts.

2.) Compare intensities of roasted peanut descriptors for Sunrunner, SunOleic, and Spanco peanuts over time by sensory evaluation of stored roasted peanuts.

3.) Compare rates of aging for Sunrunner, SunOleic, and Spanco peanuts by sensory evaluation of stored roasted peanuts.

4.) Compare consumer preferences for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting.

5.) Compare consumer preferences for Sunrunner, SunOleic, and Spanco peanuts after aging.

6.) Compare hexanal levels for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting.

7.) Compare increases in hexanal levels for Sunrunner, SunOleic, and Spanco peanuts after aging.

8.) Compare rates of increase in hexanal levels for Sunrunner, SunOleic, and Spanco during aging.

Assumptions

The author assumes the following:

1.) Sensory evaluation by a trained panel produces data that assists in determination of the true attributes of food products.

2.) With appropriate training, panelists will develop the skills necessary for sensory evaluation to provide sensitivity and reliability in recognition of a food product's particular characteristics.

3.) After completion of training, a sensory panel will diligently use the skills developed during training to evaluate the characteristic attributes of the roasted peanuts and the data generated will reflect the perceptions of the panel.

4.) Cold storage of peanuts prior to roasting adequately slowed any natural aging that might affect flavor of the peanuts before roasting.

5.) Packaging and storage conditions for the roasted peanut samples were adequate for the objectives of this research.

Limitations

The total number of panelists trained for the sensory panel was 22. The maximum number of panelists participating in a testing session was 22, and the minimum number of panelists participating in a testing session was 6.

Consumer panel testing was conducted on the basis of a forced choice with no option to decline making a preferential choice.

Consumer panel test subjects did not represent a true random sample of the total population.

Hypotheses

The following hypotheses were postulated for this research:

H_1: There will be no significant difference among the varieties of freshly roasted peanuts in the intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm.

H_2: There will be no significant difference as a result of aging over time among the varieties of sample peanuts in the intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm.

H_3: There will be no significant difference among the varieties in the rate of increase over time in intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm.

H_4: There will be no clear preference shown among the varieties of freshly roasted peanuts in consumer preference testing.

H_5: There will be no clear preference shown among the varieties of aged peanuts in consumer preference testing.

H_6: There will be no significant difference in hexanal levels among the varieties of freshly roasted peanuts.

H_7: There will be no significant difference in hexanal levels among the varieties of aged peanuts.

H_8: There will be no significant difference in the rates of increase in hexanal levels among the varieties of aged peanuts.

Format of Thesis

The study discussed in Chapter 3 was outlined and written for publication according to the Style Guide for Research Papers of the Institute of Food Technologists. The literature citations referenced in Chapter 3 will be cited in the Selected Bibliography.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to determine the effects of storage time on the sensory characteristics of three types of roasted peanuts: Florida Sunrunner, Florida SunOleic 95R, and Oklahoma Spanco Spanish peanuts. This literature review opens with information surveying lipids, fatty acids, oxidation, and development of "off flavors" in foods. A review relating to factors affecting perceived flavors in peanuts follows. This is followed by a discussion regarding the use of sensory evaluation as a research tool.

Lipids

All living systems are composed of basic elements in specific combinations. This specificity in the carbon, oxygen and hydrogen combinations results in fats and carbohydrates, while addition of nitrogen is necessary for proteins. Lipid is the term used to describe compounds that are organic, widely distributed, found in "natural" foods, insoluble in water, and soluble in non-polar solvents (St. Angelo, 1996; Meyer, 1982, Freeland-Graves and Peckham, 1987). Lipids serve as a primary source of fuel for living organisms, acting as the storage form of energy, but not contributing structural strength to plant and animal tissues. They provide a source of metabolic energy, essential fatty acids, and fat-soluble vitamins. Additionally, lipids contribute to the overall quality of food by providing a variety of flavor and character notes, such as aroma, color, texture, flavor and mouthfeel, which combine to make foods acceptable and desirable. However, when lipids are oxidized, they lead to products that are detrimental to these lipid functions (St. Angelo, 1996).

Lipid Oxidation

Natural fats commonly contain oleic acid, an unsaturated fatty acid, having 18 carbon atoms with one double bond between the ninth and tenth carbon atoms. Linoleic acid, also commonly found in natural fats, has 18 carbon atoms and two double bonds, one appearing between the ninth and tenth carbons and one between the twelfth and thirteenth (Meyer, 1982). All unsaturated fatty acids, including oleic acid and linoleic acid, are highly prone to oxidation, but the stability of an oil can be improved by decreasing the polyunsaturated fatty acids (e.g., linoleic) and increasing the monounsaturated fatty acids (e.g., oleic) (Roozen et al., 1994a, St. Angelo et al., 1973; Moore et al., 1989). Oxidation of linoleic and oleic fatty acids occurs via several pathways, and although the first step of the oxidation produces an odorless intermediate, that intermediate breaks down further into molecules which carry off-flavors (Hamilton, 1983). Autoxidation occurs when the substrate unsaturated fatty acid is oxidized, forming intermediate products which are capable of further catalyzing the reaction. This begins an autocatalytic process by which the oxidative products themselves continue catalyzing the reaction, which results in an increasing rate of reaction over time (St. Angelo, 1996).

Temperature, oxygen, light, metals, enzymes, and some microorganisms can activate autoxidation. The hydroperoxides that are formed during the oxidation of triglycerides and fatty acids decompose rapidly to form secondary reaction products, such as aldehydes, ketones, alcohols, acids and hydrocarbons. Many of these products contribute off-flavors and odors (St. Angelo, 1996; Fritsch and Gale, 1977). The degree of unsaturation of a fatty acid is inversely related to the rate at which oxidation occurs. (Moore et al., 1989). Oxidation of linoleic acid takes place 64 times faster than oxidation of oleic acid, and linolenic acid is oxidized 100 times faster than oleic. During the initial stage, oxidation takes place slowly and at a uniform rate, but when the rate of oxidation has proceeded beyond a certain level, it accelerates rapidly, resulting in oxidation reactions that proceed at many times the initial oxidation rate. It is at this point that off-flavors begin to be noticed (Hamilton, 1983). In vegetable oils, autoxidation affects the total composition of the oil over time, as the percentage of linoleic acid decreases markedly during storage periods of 9 months or more (Semwal et al., 1996). Lipid oxidation, which is an autocatalytic reaction, has been shown to increase exponentially over time, until the termination phase is reached (Fritsch et al., 1997). Initiation of oxidation is the first phase of autoxidation, the slow phase. Propagation is the second phase, where the rapid branching chain reactions take place and peroxides are generated. The third phase, termination, is marked by the distinct slowing of oxidation and recombination of many of the free radicals formed during the propagation phase (Hudson, 1983; Rossell, 1983).

During oxidation a wide range of hydroperoxides can be formed, resulting in production of a wide range of aldehydes. These aldehydes give rise to a range of flavors described in terms such as sweet, pungent, fatty, green, fruity or oily, depending upon which aldehyde has been formed and at what level it is present. Hydrolytic reactions, including lipolysis, break triglycerides down to keto acids, thus releasing hydroxy fatty acids, and contributing free oleic, linoleic, and linolenic acids for autoxidation. Flavor terms associated with the ketones and the aliphatic acids range from pungent, sweet, fruity and fatty, to sour, vinegary, and sweaty (Hamilton, 1983). Of these two types of oxidation which lead to rancidity, hydrolytic and autoxidative, it is the hydrolytic action, caused by the release of the free fatty acids from triglycerides, which is most important in determining flavor changes in foods. However, in addition to causing detrimental flavor changes, oxidative rancidity also causes formation of toxic compounds, such as oxidized sterols, polymeric material, and peroxidized fatty acids and their end-products within the rancid fats (Sanders, 1983).

Lipid Oxidation and Production of Volatile Compounds

The derivation of rancid flavors from unsaturated fatty acids results in chemically complex flavors that can be the result of any of several mechanisms. Even small amounts of the oxidative aldehyde and ketone end products are recognizable by the human sense of taste. As linoleic acid is oxidized, *cis*-3-Hexanal, *cis*-4-Hexanal, and *trans*-2-*trans*-4-decadienal are produced. Green bean and green flavor notes are attributed to *cis*-3-Hexanal and *cis*-4-Hexanal, respectively, and stale frying oil flavor notes are attributed to *trans*-2-*trans*-4-decadienal (Hudson, 1983). In testing the volatile compounds resulting from oxidation of oleic or linoleic acids, Roozen (1994a) states that gas chromatography reveals that heptane and octane are produced more readily by oleic rich oils, while pentane, pentanal and hexanal are produced in large amounts by linoleic rich oils. The peak area ratio for pentane, pentanal and hexanal is 5:4:100, showing hexanal to be a reliable measure of hydroperoxide decomposition resulting from oxidation of linoleic acid. Hydroperoxides formed by oxidation of linoleic acid decompose into relatively high amounts of hexanal, and both the rate and the yield of the hexanal are dependent mainly on autoxidation (Roozen, 1994b). In storage tests on a variety of products, rancid odors are noted when the hexanal concentration in the samples increases to 5 to 10 PPM. Prior to onset of rancid odors, there are no significant changes in the chromatogram patterns of volatiles other than the hexanal. Results of these tests indicate that hexanal denotes deterioration of the products well before the appearance of rancid odors (Fritsch and Gale, 1977). Use of the hexanal method has proven effective in a variety of formats, having been used to study effects of packaging materials, conditions of processing, and changing ingredients on development of rancidity in products.

Peanuts

Peanuts generally contain 45-50% lipids (vegetable oils), comprised of up to 12 unsaturated fatty acids, which are highly susceptible to oxidation. However, only three fatty acids make up 90% of the total lipid profile: 10% is palmitic (16:0), a saturated fatty acid which is not subject to oxidation. The unsaturated components of the remaining 80% of the oil profile are linoleic (18:2) and oleic (18:1) acids. While the oxidation of these unsaturated fatty acids is the result of lipoxygenase activity in raw peanuts, autoxidation occurs in roasted peanuts long after high temperature has caused enzymatic activity to cease (Divino et al., 1996; Pattee and Knauft, 1995; Moore and Knauft, 1989). The presence of high levels of polyunsaturated fatty acids renders peanuts quite sensitive to oxidation. So one major factor affecting the final flavors and aromas in roasted peanuts is the stability of the particular combination of fatty acids comprising the peanut (Braddock et al., 1995).

Factors Affecting Peanut Flavor

While the fatty acid ratio is of great importance, a variety of other factors affecting the character of the roasted flavor of peanuts have been the subject of a wide range of research. Variations in flavor between various peanut cultivars and breeding lines have been examined (Pattee and Giesbrecht, 1990). The mechanistic relationships occurring between particular aldehydes and pyrazines produced during lipid oxidation and the changes in flavor over time has been investigated (Warner et al., 1996). Analysis of the amino acid and sugar content of raw Virginia-type peanuts has been performed in an attempt to predict sensory scores (Oupadissakoon and Young, 1984). Research into the specific effects of cold storage on peanut quality has documented that deterioration of quality decreases with cold storage of raw peanuts. Further research has investigated the relationship between peanut seed size, the length of storage time, and the flavor and color of the roasted peanuts, showing that the oxidative stability of raw peanuts decreases for smaller seeds and longer storage times, with blanchability of the seeds after roasting also being significantly affected (Pattee et al., 1982). Research has confirmed the importance of oxygen concentration, relative humidity, and the roasting process in the oxidation of peanuts. Edible coatings with low oxygen permeability and nitrogen-flushing of oxygen-barrier product packaging have been examined as potential methods for extending shelf life by reducing lipid oxidation (Mate et al., 1996). Optimal roasting color for peanut samples has also been investigated, and small differences in color of roasted peanuts has not been a major contributing factor to the flavor differences noted among samples (Pattee et al., 1991; Sanders et al., 1989). In addition, the effects of curing treatments and peanut maturity on roasted peanut flavor have been studied, noting that differences in roasted peanut flavors are possibly due to effects of different curing treatments on peanuts of different maturity in sized peanut lots (Sanders et al., 1990). It is evident that a wide variety of factors contribute to the final roasted peanut flavor.

High levels of polyunsaturated fatty acids in peanuts contribute directly to early rancidity in peanut oils. The desire to minimize the rate of oxidative changes in peanuts resulted in the investigation of selective breeding for peanut lines having higher proportions of oleic acid because extending storage time while retaining flavor stability decreases product losses due to degradation, and is therefore beneficial not only for the processors but also for the consumers of the peanut products (Pattee and Knauft, 1995; Braddock et al., 1995; Moore and Knauft, 1989).

Braddock, Sims and O'Keffe (1995) reported on the testing of high oleic acid peanuts, with approximately 80% oleic and 3% linoleic acid against normal peanuts to evaluate sensory characteristics and volatile oil gas chromatography profiles over time. Shelf life of the high oleic acid peanuts was estimated from the combined sensory and physical data as being twice the shelf life of normal peanuts. They note that the aromas of aldehydes which are generated from oxidation of oleic and linoleic acids in the two different types of peanuts may affect the kinds of off flavors which occur in the aging process. They also reported that the high oleic acid peanuts exhibited fewer off flavors and maintained a more pleasing flavor during storage. Painty and cardboardy flavors, as well as dark roasted flavor notes were compared between the lines. Over time, the dark roast character almost disappeared in both lines, while the painty and cardboardy off-flavors were higher in the normal peanuts.

Sensory Evaluation

The excellence of a product is irrelevant if consumers do not appreciate the product enough to make the purchase. Product acceptance is not homogeneous across a population, nor are the attributes that consumers appreciate necessarily ones producers have regarded as most important. Consumers, in fact, may not recognize the roles of ingredients, processing and quality control procedures that improve the quality and value of a product. However, manufacturers have recognized their need to know what consumers think because product quality has a strong impact on consumer behavior. Although information regarding consumer perception of quality is readily available, applying this information is challenging.

Sensory analysis is a method for identifying product qualities that are important to the consumer (Stone et al., 1991). Sensory analysis testing is divided into two major classifications: affective testing, which evaluates preference and/or acceptance of products, and analytical testing, which evaluates differences or similarities between products, or identifies and quantifies sensory characteristics. Affective testing utilizes untrained panel members who may be selected based on predetermined criteria, such as location, age, product usage, socio-economic status, size of family, etc. Analytical testing is further divided into discriminative and descriptive testing, both of which employ trained and/or experienced panelists with the ability to generate consistent and reproducible results (IFT Sensory Evaluation Division, 1981). For panelists performing affective testing, such as consumers, it is a necessary part of the strategy for them to not be overfamiliarized with the product being tested, or they cease being untrained. Unlike affective testing, however, the primary goal of analytical sensory evaluation is to use human beings and their sensory abilities as complex laboratory instruments to measure characteristics of food (O'Mahony, 1995; Mancini, 1992; Rutledge and Hudson, 1980).

Project Design for Sensory Evaluation

Clearly set objectives are essential to every project utilizing sensory analysis, whether affective or analytical. The objectives for the project define the testing design. Testing methods, which are either selected or developed, must be suitable for the specific objective. For instance, if the objective is to investigate consumer preferences, consumers are the logical choice for panelists. Any training renders those consumers atypical of the consumer population, and should be avoided (O'Mahony, 1995; Lawless, 1994). Since affective tests evaluate preference and/or acceptance of products, a large number of panelists is needed, usually 50 - 100, and the panelists are selected to represent a larger target audience. Preference measurement may ask the panelist to choose one sample over another, to put sample products in order based on a characteristic, or express an opinion on a hedonic scale. Paired-preference, ranking and rating tests are methods appropriate for consumer panel testing (IFT Sensory Evaluation Division, 1981).

On the other hand, when the objective of the testing is to measure specific sensory characteristics of one product, perhaps over time, or to determine similarities of characteristics of several products, sensitivity and reliability of the panelists must be assured. Training the panel to develop sensitivity and reliability in recognition of the particular characteristics is needed, a task accomplished by repeated familiarization with standards, thus calibrating the human instruments (O'Mahony, 1995; Mancini, 1992; Rutledge and Hudson, 1980). Analytical sensory panelists are screened for interest in the work and for discriminative abilities before being trained to reproduce results and function as calibrated instruments. Usually analytical panels consist of 10 or more panelists, with an absolute minimum of 5 panelists recommended to avoid excess dependence on responses of any one panelist. A wide variety of methods are available for analytical sensory analysis, falling into one of two general categories: discriminative testing, used for measuring whether samples are different, or descriptive testing, used for measuring qualitative and/or quantitative characteristics of the product(s). Further classification of discriminative tests is also possible: difference tests, such as paired-comparison, duo-trio, triangle, ranking and rating, or sensitivity tests, such as threshold and dilution. Descriptive testing can measure attribute ratings, using category scaling or ratio scaling, or descriptive testing can be used to perform descriptive analyses, such as flavor profile analysis, texture profile analysis, or quantitative descriptive analysis (IFT Sensory Evaluation Division, 1981).

Panel Selection for Sensory Evaluation

Selection of panelists appropriate for both the testing objectives and methods is important. Descriptive panelists are trained to focus on individual attributes of a product and fully analyze the component flavor notes. Their training enables them to notice many attributes that generally go unnoticed by consumers, who look at products as whole systems rather than as specific combinations of sensory properties. Consumers give an integrated response, but a sensory panelist no longer responds in like manner. Therefore, it is important not to present descriptive panelists with conflicting test objectives, such as combining preference questions with descriptive analysis questions. Selection of appropriate objectives, test methods, and appropriate panelists for the chosen tests are all factors which contribute directly to the reliability of the sensory testing as it is performed

(Lawless and Claassen, 1993).

When working with well-trained panels, British research has suggested that panels greater than about 6 are not necessary, and that panels larger than 6 may not achieve additional accuracy (Cook and Homer, 1996). Testing of descriptive panels has shown a positive relationship between training procedures, length of training, and panel performance. The greater the length of training, thus increasing familiarity with both panel procedures and product characteristics, the more consistent and reproducible the responses of the panelists. Generally, this is due to the increased experience utilizing descriptive terms, as well as learning a greater depth of discriminative skills. Training did not distort panelists flavor perceptions, but did magnify or sharpened it (Wolters and Allchurch, 1994). Training of descriptive panelists introduces them to the component parts of flavor: tastes (bitter, sweet, sour, salt), chemical feeling factors (sensations to the nerve endings in the mouth and nose, such as astringency, pungency, heat, cooling, etc.), and aromatics (olfactory sensations from food volatiles in the mouth). It is essential for descriptive panelists to understand that their task is to break food down into those component parts and express the components in numbers representative of the relative intensities of the component parts, a task accomplished by utilizing standardized reference foods and solutions to anchor the scores (Rutledge, 1992; Rutledge and Hudson, 1990).

With modification of fatty acid ratios, flavor changes occur in peanuts due to the changes in the lipid fractions and the fatty acid distribution. Identification and comparison both of initial flavor attributes and of changes in those flavor attributes over time for peanuts with differing oleic: linoleic acid ratios provides information regarding the differences encountered during aging among the different varieties.

CHAPTER III

A COMPARISON OF ROASTED PEANUT FLAVOR ATTRIBUTES OVER TIME FOR THREE PEANUT CULTIVARS WITH DIVERS OLEIC: LINOLEIC ACID RATIOS

Introduction

The primary purpose of this study was to compare intensities of roasted peanut flavor attributes for Florida Sunrunner, Florida SunOleic 95R, and Oklahoma Spanco Spanish peanuts within 48 hours of initial roasting and to repeatedly compare those flavor attributes over time by means of sensory evaluation of the roasted peanuts by a trained descriptive panel. The second purpose of this study was to compare consumer preferences for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting and to compare consumer preferences after aging the peanuts. And the final purpose of this study was to compare the hexanal levels for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting and to repeatedly compare those levels over time by means of gas chromatography. The following sections will cover the materials and methods utilized in preparation of the samples, sensory evaluation, data collection, experimental design and statistical analysis, and the results and discussion.

Materials and Methods

Sample Preparation

Raw peanuts destined to become samples for sensory evaluation were roasted as a single batch to eliminate variation in roasting times, temperature, or methods across a particular cultivar. Only one cultivar was roasted at a time to eliminate the possibility of mis-identification of the roasted peanuts. Each cultivar batch was roasted using the same procedure, which began with preheating the ovens to 350^{O}F. Four cups of raw, shelled peanuts of a single cultivar were measured onto insulated baking sheets that measured 12 x 18 inches. Hand culling removed broken, discolored, misshapen, bug-eaten, and overly wrinkled peanuts. Peanuts with no paper skins and peanuts that were much larger or smaller than the "average" peanut of the lot were also removed before roasting began. The peanuts were spread evenly in a single layer on the pans and placed in the ovens.

Roasting was regulated utilizing two ovens, one gas and one electric, rotating the baking sheets between the ovens every 10 minutes. Additionally, the peanuts were thoroughly agitated each time they were moved between ovens to minimize hot spots on the peanuts. Further regulation of roasting required rotating the baking sheets between the top and bottom oven shelves at 5-minute intervals. These methods allowed each pan to spend an equal amount of time in the gas and electric ovens, as well as spending as equalizing time spent on the top and bottom shelves within each oven. When the color of the roasted peanuts closely approximated the color standard, the cooking was stopped by removing the pans from the ovens and transferring the roasted peanuts to cooling screens for quick cooling by forced air with continuous agitation. (The color standard utilized for this study was a commercially available confection, which is covered with roasted peanuts.) To most closely approximate the color standard, the Sunrunner peanuts required a total of 50 minutes to roast, the SunOleic required 55 minutes, and the Spanco peanuts required 45 minutes. Upon reaching room temperature, agitation of the peanuts was discontinued, but the forced air cooling continued for an additional 30 minutes, with periodic agitation, to ensure all peanuts were completely cooled. The cooled roasted peanuts were placed in large plastic containers that were clearly tagged for easy identification. The containers were covered for storage and wrapped in black plastic and moved into a dark room for storage until the controlled environment packaging and placement could be completed, 10 days later.

Samples for the initial sensory evaluation testing were prepared approximately 48 hours after roasting. Individual one-ounce samples of each of the roasted peanut cultivars were measured into color-coded two-ounce plastic soufflé cups and capped. Individual one-ounce samples of the roasted peanut standard were measured into unmarked two-ounce plastic soufflé cups and capped. One of each of the three color-coded samples and one standard were prepared for each sensory panelist. After the initial samples were taken, the roasted peanuts were packaged for storage in the environmental control chamber, where they were stored until needed for testing purposes.

The packaging for storage in the environmental control chamber for each cultivar utilized the following methodology: First, two cups of roasted peanuts were placed in each color-coded polyethylene package. Atmospheric air was evacuated from each bag, down to one inch of mercury (1 in. Hg), and a mixture of 21% oxygen and 79% nitrogen was introduced into the bag. Each bag was sealed and all packages of each cultivar were placed in a plastic storage container and the lid was snapped in place. The storage container was enclosed in black plastic and placed in an environmental control chamber at 30^{O}C. Packaging in 2-cup random lots drawn from the total roast batch of each cultivar allowed for ease in obtaining sufficient sample material for each testing session without an opportunity to contaminate the remaining roasted sample materials.

In preparation for the continuing sensory evaluation of the aging roasted peanuts, one color-coded bag of each cultivar was randomly chosen and removed from the environmental control chamber and brought to room temperature in the experimental food laboratory. For each test session of the aging roasted peanuts, one-ounce samples of each of the three roasted peanut cultivars were measured into color-coded two-ounce plastic soufflé cups and capped, and one-ounce samples of the standard roasted peanuts were measured into unmarked two-ounce plastic soufflé cups and capped. One of each of the three color-coded two-ounce plastic soufflé cups and one of the standard two-ounce plastic soufflé cups were prepared for each sensory panelist.

All peanut samples for gas chromatographic hexanal analysis and for CIE L*a*b* color analysis were obtained directly from the packaged and marked sensory evaluation samples to ensure random sampling. Two of each of the color-coded two-ounce plastic soufflé cups and two of the standard two-ounce plastic soufflé cups were prepared for each gas chromatographic hexanal analysis. Two of each of the color-coded two-ounce plastic soufflé cups and two of the standard two-ounce plastic soufflé cups were also prepared for each CIE L*a*b* color analysis test session. (For CIE L*a*b* Color Analysis procedures and results, see Appendix A).

Freshly roasted peanuts of each cultivar were necessary for all consumer preference testing of the fresh roasted peanuts. This required roasting within 48 hours of testing. Oven roasting of peanuts of each cultivar was performed utilizing the methods previously described. After cooling, the roasted peanuts were sealed in color-coded plastic food storage bags until they were portioned into individual sample cups. Portioning and marking of consumer preference samples was performed as previously described. One of each of the three color-coded two-ounce plastic soufflé cups was prepared for each consumer preference panelist. Preparation of samples of aging peanuts for consumer preference testing was performed in the same manner as for the sensory evaluation samples, with the following exception: two matching color-code labels were affixed to each of the two-ounce plastic soufflé cups to indicate the samples were aged. Consumer preference panelists did not receive samples of the standard peanuts for tasting.

Sensory Evaluation Participants and Training

The participants selected for the sensory evaluation panel were 22 healthy female volunteers from the Oklahoma State University community. Ages of the sensory evaluation panelists ranged from 21 to 45 years. Prior to the initial testing session, sensory panelists participated in several hours of training in sensory evaluation and descriptive panel methodology in weekly 45 – 60 minute sessions extending over a 6-week period. Panelists were first introduced to identification of basic tastes, aromatics, and chemical feeling factors that are inherently involved in flavor. Panelists learned to evaluate the intensity of sensory data and assign numerical values to those intensities by using reference standards. Sampling techniques routinely used by panels performing quantitative descriptive analysis, such as pinching the nostrils to block aromatics while determining the basic tastes present in a sample, were learned and practiced repeatedly

(ASTM, 1992). Reference standards were used regularly and became the foundation for the intensity ratings throughout the study. Panelists learned to employ group discussion to reach consensus ratings on a variety of sample materials. Through panelist training, recognition of an attribute in a specific sample became based on training rather than on the previous personal experience of each panelist. Physiological sensitivity was explained and demonstrated to panelists, and specific rules for training and testing were set forth and accepted by panelists, in accordance with Sensory Testing Methods: Second Edition (ASTM, 1996).

After training on both fresh and rancid sample materials, panelists utilized their training to identify basic tastes, aromatics, and chemical feeling factors found in samples of the standard unsalted dry roasted peanuts that would serve as reference throughout the testing sessions. Panelists were instructed to blanch the sample peanuts, place 4 to 5 peanut halves between their molars and to chew 4 to 5 times to release the flavors. They were first to identify the basic tastes present in the sample and then to release the aromatics as they had been taught. A list of peanut flavor attributes, adapted from A Lexicon of Peanut Flavor Descriptors by the USDA, was supplied to each panelist to assist as the group chose the flavor attributes and definitions for the flavors they identified in the peanuts. A ballot was prepared indicating the flavor attributes identified by the panel and a practice evaluation was done. Panelists assigned intensity values for the individual flavor attributes of the standard dry roasted peanuts through balloting, discussion, and consensus in final preparation for descriptive analysis of the sample products.

Participants in the consumer preference panels were 78 healthy volunteers from the

Oklahoma State University community. Consumer participants ranged from adolescent middle school students to middle-aged parents of OSU students. No training was given to participants in the consumer preference panels.

The sensory evaluation score sheets were scored by the panelists by marking their findings for each sensory attribute on a numerical rating scale (0 – 10) to signify increasing intensity. The panelist identified the response for each sample by the color code on the sample container. Accuracy in assignment of values to the panelists' marked responses was facilitated by use of an acetate template grid and a light table: each score sheet was affixed in a precise location on the template and the template markings were backlit, clearly "marking" the score sheet with the marks from the underlying grid. The value of each response was then marked on the score sheet and all scores were tabulated.

Data Collection: Sensory Evaluation Panel

Testing sessions for the sensory evaluation panel took place over a 6-month period. Sessions were held in classrooms with ambient temperature and lighting. Environmental sounds and odors were minimized. Distilled water was supplied to each panelist for mouth rinsing before and between samples. At each testing session, panelists first tasted the standard peanuts in order to refamiliarize themselves with the flavor attributes and decide whether the values set for the standard required adjustment. Discussion followed and group consensus was accepted.

For testing, sample presentation order was initially randomized and then specific presentation order was noted on each sensory evaluation data sheet. Panelists were instructed to taste samples in the order given on their sensory evaluation data score sheet. They were to blanch the samples before tasting, place 4 to 5 peanut halves between their molars, and chew 4 - 5 times to release the flavors. Each panelist was to identify the basic tastes present in the sample, release the aromatics as they had been taught, set intensity values for each of the attributes, and record their results on the bipolar evaluation scales on the sensory evaluation data sheet. Discussion of individual impressions and scoring was discouraged during the sample evaluation sessions and scoring to facilitate and encourage individual objectivity. Figure 1 is a copy of the sensory evaluation score sheet.

Data Collection: Consumer Preference Panels

Consumer preference tests were conducted in classrooms with ambient temperature and lighting. Environmental sounds and odors were minimized. Distilled water was supplied to each panelist for mouth rinsing before and between samples. Sample presentation order was randomized and the presentation order was specified on each data score sheet. At the beginning of the testing session, the consumer preference panelists were told to taste the samples in the order set forth on the data score sheet. They were instructed to blanch the peanut samples and taste 4 - 5 peanut halves at one time, then to mark the data sheet to indicate the color of the sample which they "like the best" and the color of the sample which they "like the least". Figure 2 is a copy of one of the 6 randomized data score sheets used for the consumer preference panels rating fresh roasted peanuts. Figure 3 is a copy of one of the 6 randomized data score sheets used for the consumer preference panels rating aged peanuts.

Sensory Panel Evaluation *Date / Time*__________ #______

Directions: Place straight lines through the scales indicating your sensory evaluation and label your marks with the corresponding number(s) on the samples. A score of 0 on the scale is low intensity, and 10 is very intense. (Each scale will have 4 marks when you have completed your evaluation.) Taste samples in this order:

Basic Tastes

Sweet

0 1 2 3 4 5 6 7 8 9 10

Sour

0 1 2 3 4 5 6 7 8 9 10

Bitter

0 1 2 3 4 5 6 7 8 9 10

Salt

0 1 2 3 4 5 6 7 8 9 10

Aromatics

Peanutty

0 1 2 3 4 5 6 7 8 9 10

No Roast ... Dark Roast

Sweet aromatic

0 1 2 3 4 5 6 7 8 9 10

Cardboard

0 1 2 3 4 5 6 7 8 9 10

Painty

0 1 2 3 4 5 6 7 8 9 10

Fishy

0 1 2 3 4 5 6 7 8 9 10

Woody

0 1 2 3 4 5 6 7 8 9 10

Earthy

0 1 2 3 4 5 6 7 8 9 10

Skunky

0 1 2 3 4 5 6 7 8 9 10

Feeling Factors

Astringent

0 1 2 3 4 5 6 7 8 9 10

Mouth film/coating

0 1 2 3 4 5 6 7 8 9 10

Figure 1. A copy of the sensory evaluation data sheet used by the trained panel.

Consumer Preference Sensory Evaluation Testing

Please taste each of the samples in the following order:
Green
Blue
Orange

Mark the box with the color of the sticker on the peanuts which you like the **best:**

☐ Orange ☐ Green ☐ Blue

Mark the box with the color of the sticker on the peanuts which you like the **least:**

☐ Orange ☐ Green ☐ Blue

Thank you for helping us with this research.

Figure 2. A sample of one of the 6 randomized data score sheets used by the consumer preference panels rating fresh roasted peanuts.

Consumer Preference Sensory Evaluation Testing

This taste test is like the first test, but **each sample cup has two color dots.**
Please taste each of the samples in the following order:
Green
Blue
Orange

Mark the box with the color of the sticker on the peanuts which you like the **best:**

☐ Orange ☐ Green ☐ Blue

Mark the box with the color of the sticker on the peanuts which you like the **least:**

☐ Orange ☐ Green ☐ Blue

Thank you for helping us with this research.

Figure 3. A sample of one of the 6 randomized data score sheets used by the consumer preference panels rating aged peanuts.

Data Collection: Hexanal

Peanut halves of a single cultivar were uniformly ground to a particle size of less than 1mm for packaging in 2-dram vials. Six (6) 50-mg samples were used for each cultivar at each testing session. Prior to sealing the 2-dram sample vials with Teflon-lined silicon septa, an internal standard was added. For this internal standard, 4-heptanone was dissolved in canola oil. The vials, with the mixture of ground peanuts and the internal standard, were then incubated at 90°C for 15 minutes.

A gas chromatograph equipped with a split injector (split ratio 1:50) and FID detector was used to analyze headspace gas (1 ml) from the incubated vials. Within the gas chromatograph, the injector temperature was 275°C and the detector temperature was 300°C. Separations were carried out using a DB 23 fused silica capillary column (30 m x 0.25 mm I.D., J & W Scientific, Rancho Cordova, CA). The temperature of the column oven was maintained at 50°C for 2 min, then the temperature was increased at a rate of 10°C / min for 4 min. The oven temperature was returned to 50°C prior to injection of a new sample. The entire process was followed for each of the peanut cultivars at each testing session.

Experimental Design and Statistical Analysis

The sensory evaluation study was a repeated measures experiment designed to generate data regarding the effects of storage time on selected sensory characteristics of three types of roasted peanuts: Sunrunner, SunOleic, and Spanco peanuts. The specific order of presentation of the sample peanuts was predetermined to ensure that each variety appeared before and after each of the other varieties an equal number of times during each testing session whenever possible. The order of presentation was manipulated to ensure that no sensory panelist began testing with the same variety more than twice in succession. At each test session, the unsalted dry roasted standard peanut was used as a reference. The sensory characteristics selected for balloting were the basic tastes: sweet, sour, bitter, and salt; the aromatics: peanutty, sweet aromatic, cardboard, painty, fishy, woody; and the feeling factors: astringency and mouthfilm. The aromatics earthy and skunky were included at the specific request of the sensory panel immediately after the second week of storage, when the panelists identified the two new aromatics in the aging samples.

Analysis of Variance (ANOVA) was performed for each sensory attribute of the fresh roasted peanuts. Correlation analyses were performed among all sensory attributes and time for each variety. Sensory attributes which demonstrated strong trends over time were further analyzed using Analysis of Covariance (ANCOVA), comparing the vareiety means at specific times. For attributes that did not exhibit a trend over time, analysis of variance was performed for each attribute of the aging peanuts at 7 and 11 weeks in storage. Least Squares Means (LSMeans) were used to separate variety means when ANOVA tests were significant.

The consumer preference study used a randomized block design to model data from the preference of consumers faced with the three varieties of peanuts in a forced-choice test. Requiring panelists to mark both "like the best" and "like the least" provided ranked data for the three choices in each test. The consumer preference data for fresh roasted and aged peanuts were analyzed, using ANOVA, as separate studies in randomized complete block designs where the ages of the samples were the treatments.

Hexanal analysis generated data regarding increase in hexanal (in parts per million) occurring over time. Testing was performed for each of the three varieties at each test session, and a standard was tested in most sessions. Hexanal levels and sensory attributes for each variety were examined using correlation analyses. Hexanal levels over time were analyzed by ANCOVA methods to compare mean responses among the Sunrunner, SunOleic, Spanco peanut varieties and a standard.

Results and Discussion

Sensory Evaluation Data

The initial ballot of sensory attributes chosen by the sensory evaluation panel was comprised of 12 terms that each of the panelists learned to identify and quantify during the training and practice sessions. The level of training achieved by the panelists became evident during the third week of evaluation of the aging samples, when the panelists informed the researchers that two aromatics had developed in the samples. By referring to A Lexicon of Peanut Flavor Descriptors (Johnsen, 1986), the panelists identified the "new" aromatics by the descriptors "earthy" and "skunky", and the terms were added to the score sheet. Since the panel had not identified those attributes during any prior testing session in either the fresh roasted peanuts or in the standard peanuts, values for those attributes were set as 0 (zero) for those attributes on the earlier sessions on advice of the statistician. Addition of earthy and skunky as attributes for this study raised the number of attributes for evaluation by the sensory evaluation panel to a total of 14.

Analyses on Fresh Roast Peanuts

ANOVA was performed for each sensory attribute for the freshly roasted peanuts.

No significant differences were indicated among the varieties for the following taste attributes: sweet and salt; the aromatics: cardboard, painty, fishy, earthy, and skunky; and for the chemical feeling factor mouthfilm ($p > 0.05$). LSMeans indicated significant differences for each of the following taste attributes: sour and bitter; aromatics: peanutty, sweet aromatic, and woody; and for the chemical feeling factor astringency (see Table 1).

Table 1. Least Squares Means and Standard Errors for specific attributes for each variety at Week 0 (fresh roast).

Attributes \ Varieties	SunOleic	Sunrunner	Spanco
SOUR	1.1861[a] *(0.1516)*	1.0210[a] *(0.1460)*	0.6075 *(0.1360)*
BITTER	1.9093 *(0.2386)*	1.1538[a] *(0.2386)*	0.6440[a] *(0.2222)*
PEANUTTY	4.7493[a] *(0.4892)*	5.4493[a] *(0.4892)*	2.2711 *(0.4557)*
SWT AROMATIC	1.9431[a,b] *(0.2540)*	1.6209[a] *(0.2540)*	2.3414[b] *(0.2366)*
WOODY	3.7848[a] *(0.2467)*	3.7682[a] *(0.2467)*	2.3577 *(0.2298)*
ASTRINGENCY	4.0409[a] *(0.2717)*	3.7687[a] *(0.2717)*	2.7548 *(0.2531)*

*Within a single attribute, means having a common superscript are not significantly different at $\alpha = 0.05$.
**Values in parentheses are Standard Errors of the LSMeans.

At fresh roast, SunOleic was more sour, bitter, peanutty, woody and astringent than Spanco, and SunOleic was more bitter than Sunrunner. Sunrunner was more sour, peanutty, woody and astringent than Spanco. Spanco had higher sweet aromatics than Sunrunner.

<u>Analyses on Aging Peanuts</u>

Preliminary correlation analyses between the mean values of sensory attributes (averaged across panelists) and time in storage showed no correlation within any of the varieties for a number of the attributes (tastes: sweet and salt; the aromatics: peanutty, sweet aromatic, and woody; and the chemical feeling factor astringency) ($p > 0.05$). However, significant positive linear trends were observed for the remaining aromatics: cardboard, painty, fishy, earthy, and skunky and for mouthfilm. Pearson correlation coefficients and their significance levels are shown in Table 3.

Table 2. Pearson Correlation coefficients (and their significance levels) between specific attributes and time (weeks) in storage for each variety.

Varieties / Attributes	SunOleic	Sunrunner	Spanco
CARDBOARD	0.8305 *(p = 0.0107)*	0.8165 *(p = 0.0134)*	0.8042 *(p = 0.0292)*
PAINTY	0.1379 *(p = 0.7447)*	0.9114 *(p = 0.0016)*	0.8276 *(p = 0.0216)*
FISHY	0.4390 *(p = 0.2765)*	0.8916 *(p = 0.0029)*	0.8358 *(p = 0.0192)*
EARTHY	0.6766 *(p = 0.0654)*	0.8574 *(p = 0.0065)*	0.9524 *(p = 0.0009)*
SKUNKY	0.6202 *(p = 0.1009)*	0.7563 *(p = 0.0299)*	0.8715 *(p = 0.0106)*
MOUTHFILM	0.1872 *(p = 0.6570)*	0.8627 *(p = 0.0058)*	0.7040 *(p = 0.0775)*

Because sensory attributes that did not exhibit a strong trend over time could still exhibit differences over time, ANOVA was performed to compare the varieties after 7 weeks in storage. No significant differences were indicated among the varieties for the following taste attributes: sweet, salt and bitter; the aromatics: peanutty, sweet aromatic, and woody; or for the chemical feeling factors astringency and mouthfilm ($p > 0.05$). However, a significant difference was found between SunOleic and Spanco ($p = 0.0017$) and between Sunrunner and Spanco ($p = 0.0024$) for sour, with Spanco being less sour than either of the other varieties, as shown in Table 2.

Table 3. Least Squares Means and Standard Errors for sour attribute for each variety at Week 7.

Varieties / Attribute	SunOleic	Sunrunner	Spanco
SOUR	1.5125[a] *(0.1527)*	1.4750[a] *(0.1527)*	0.6750 *(0.1527)*

*Means having a common superscript are not significantly different at $\alpha = 0.05$.
**Values in parentheses are Standard Errors of the LSMeans.

ANOVA was performed to compare the varieties again after 11 weeks in storage. No significant differences were indicated among the varieties for any of the attributes at the alpha level chosen for this research (0.05).

For data exhibiting a trend over time ANCOVA techniques were used to model the trends and make comparisons among means. The remaining aromatics (cardboard, painty, fishy, earthy, and skunky) increased over time. For each of these attributes, the rate of increase was adequately modeled by systems of parallel lines (see Figure 4 and Appendix B). This implies that each attribute changed at the same rate for all varieties.

Since a system of parallel lines models each attribute, varieties can be compared at any time (0 – 16 weeks in storage) to determine if variety differences exist. No differences among the varieties were found for the aromatics painty, fishy, earthy, or skunky, or the chemical feeling factor mouthfilm ($p > 0.05$). However, LSMeans indicated a significant difference between SunOleic and Spanco ($p = 0.0035$) and between Sunrunner and Spanco ($p = 0.0006$) for the aromatic cardboard. Spanco was significantly lower than either of the other two varieties (see Figure 4).

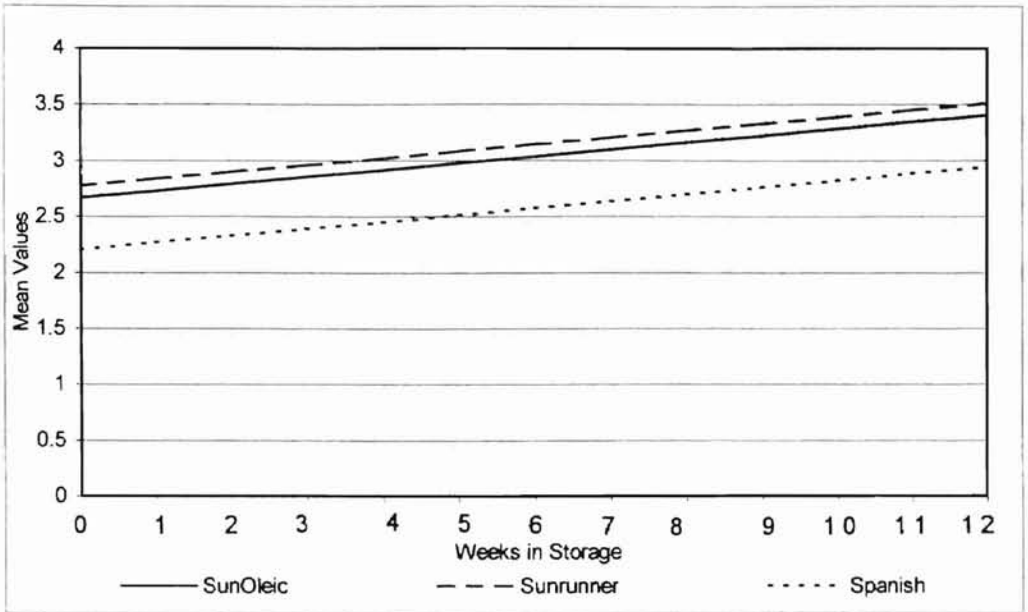

Figure 4. Cardboard attribute vs. weeks in storage.

Table 4. Least Squares Means and Standard Errors for cardboard attribute for each variety at Week 7.

Varieties / Attribute	SunOleic	Sunrunner	Spanco
CARDBOARD	3.2202[a] *(0.0986)*	3.3261[a] *(0.0986)*	2.7588 *(0.0986)*

*Means having a common superscript are not significantly different at $\alpha = 0.05$.
**Values in parentheses are Standard Errors of the LSMeans.

Sensory Discussion

The sensory evaluation panelists indicated significant differences in several of the flavor attributes of the fresh roasted peanuts. As the peanuts aged, variation in flavor attributes occurred within each variety of peanuts. Several of the attributes showed no significant differences over time among the three varieties (tastes: sweet and salt;

aromatics: peanutty, sweet aromatic, and woody; chemical feeling factor: astringency). Furthermore, the attributes that did show significant linear trends increased at the same rate in each of the varieties (aromatics: cardboard, painty, fishy, earthy, and skunky; chemical feeling factor: mouthfilm). While the aging of the peanuts brought definite flavor changes, only one attribute, the aromatic cardboard, was significantly different between any of the varieties and it, too, increased at the same rate in each of the varieties.

These increases in off flavors probably reflect the increase in aldehydes and ketones within the seeds as described by Hamilton (1983) and Sanders (1983). The parallel rates of increase with aging do not reflect the difference in rates of oxidation between oleic and linoleic acid described by Hamilton (1983), nor do they reflect the exponential escalation expected during the propagation phase of the autocatalytic processes as described by Hudson (1983), Rossell (1983), and Moore et al. (1989).

Oxidation produces a wide range of hydroperoxides that, in turn, produce aldehydes and ketones. A range of off flavors was anticipated in the research because the human tongue readily identifies very low levels of these organics. St. Angelo (1996) and Fritsch and Gale (1977) indicated that off flavors and odors are contributed by aldehydes and ketones. Identification of the attributes skunky and earthy by the panelists early in the study clearly illustrated the ability of the panel to isolate and identify flavors previously not present in the samples. These flavor attributes were most likely a direct result of oxidation producing "new" organics in the aging peanuts.

The sizeable differences in peanut kernel circumference would also be expected to significantly affect rates of aging among the varieties, as described by Pattee et al. (1982), however the results of this research did not reflect significantly different rates for the smaller Spanco peanuts. Finally, these results indicating parallel rates of increase in flavor attributes with aging do not agree with Braddock, Sims and O'Keffe (1995), who reported that high oleic peanuts exhibit fewer off flavors and maintain a more pleasing flavor during storage.

Consumer Preference Data

The consumer preference data sheets were scored and the samples were ranked using choice "liked the best" as the first choice, "liked the least" as the third choice, and the remaining sample as the second choice. The ranks were converted to scores in the manner of Fisher and Yates (1974), and the scores were subjected to ANOVA. Consumer preference data indicated no significant difference ($p > 0.05$) among the three fresh roasted varieties. There was also no significant difference between the aged samples in consumer preference testing ($p > 0.05$). (See Appendix C.)

Consumer Preference Discussion

The results of consumer preference testing demonstrated that consumers assess products much more holistically than trained sensory panelists as Lawless, et at. (1993) stated. Differences in individual taste perceptions, and the fact that consumer preference panelists were not directed to choose based on any specific attributes of the samples worked together to permit individuals to record global and integrated perceptions and responses, without considering the variety of separate flavor attributes in each sample. Since preferences result from general predisposition for certain foods, flavors, or attributes of foods, they are highly individual decisions and may indicate variations in the intensity of individual olfactory and taste perceptions (Meiselman, 1996).

The consumer panelists were given no standards of reference, and with no standards of reference, the panelists based their decisions on their first impression of each sample. Therefore, the panelists judged the samples on their own individual criteria, with full assurance that the criteria they chose to use would provide an acceptable choice. And, although all of the peanut varieties developed off flavors with aging, there was apparently no attribute or attributes that were so significantly offensive as to cause the majority of the consumers to prefer the other varieties. As stated by O'Mahony (1995), consumer data must be interpreted with caution because the panelists were not trained test takers and had no internal calibrations with which to judge. Although it is possible with some products to have consumer preference results indicating population groups whose preferences are quite different from the general population (Stone, et al., 1991), the consumer preference data for this study was designed to allow researchers to draw such conclusions. While the results of the consumer preference testing are an indicator that the three varieties are not significantly different in acceptability, they do not necessarily predict consumer consumption behavior over time.

Hexanal analysis

Hexanal was not correlated with the taste salt, the aromatics peanutty, sweet aromatic, and woody, or the chemical feeling factor astringency in any of the three varieties ($p > 0.05$), but it was correlated with sweet in SunOleic ($r = 0.8853$, $p = 0.0035$). Other correlations were identified between hexanal and the tastes sour and bitter, the aromatics cardboard, painty, fishy, and earthy, and the chemical feeling factor mouthfilm for Sunrunner and Spanco, but not for SunOleic. Table 5 shows Pearson Correlation coefficients and their significance levels.

Table 5. Pearson Correlation coefficients (and their significance levels) between specific attributes and hexanal for each variety.

Varieties / Attributes	SunOleic	Sunrunner	Spanco
SOUR	-0.3479 *(p = 0.3984)*	0.8300 *(p = 0.0108)*	0.6458 *(p = 0.1172)*
BITTER	0.5044 *(p = 0.2025)*	0.7271 *(p = 0.0401)*	0.7652 *(p = 0.0450)*
CARDBOARD	-0.2401 *(p = 0.5668)*	0.7918 *(p = 0.0192)*	0.8170 *(p = 0.0249)*
PAINTY	-0.4646 *(p = 0.2461)*	0.9093 *(p = 0.0017)*	0.8434 *(p = 0.0171)*
FISHY	-0.1058 *(p = 0.8030)*	0.8197 *(p = 0.0127)*	0.8312 *(p = 0.0205)*
EARTHY	0.1461 *(p = 0.7300)*	0.8631 *(p = 0.0058)*	0.7900 *(p = 0.0345)*
SKUNKY	0.3187 *(p = 0.9542)*	0.7445 *(p = 0.0341)*	0.6489 *(p = 0.1148)*
MOUTHFILM	0.4629 *(p = 0.2481)*	0.9012 *(p = 0.0022)*	0.7735 *(p = 0.0413)*

Further analysis of the hexanal data used ANCOVA techniques to compare trends between varieties since significant linear trends were observed ($p < 0.001$). This analysis determined that hexanal differences among the varieties at fresh roast were not significant ($p = 0.1014$). However, the production of hexanal as the peanuts aged in storage proceeded at rates that were significantly different among the varieties ($p \leq 0.0001$) (see Figure 5). LSMeans indicated no significant difference between the SunOleic and the Standard peanuts at 6 weeks of storage ($p > 0.05$), but there were significant differences between SunOleic and Sunrunner, SunOleic and Spanco, and Sunrunner and Spanco ($p < 0.05$). Hexanal levels in Spanco were the highest, and the levels in Sunrunner were higher than in SunOleic, as seen in Table 6. (See Appendix D for additional information.) No formal slope comparisons were done on hexanal data.

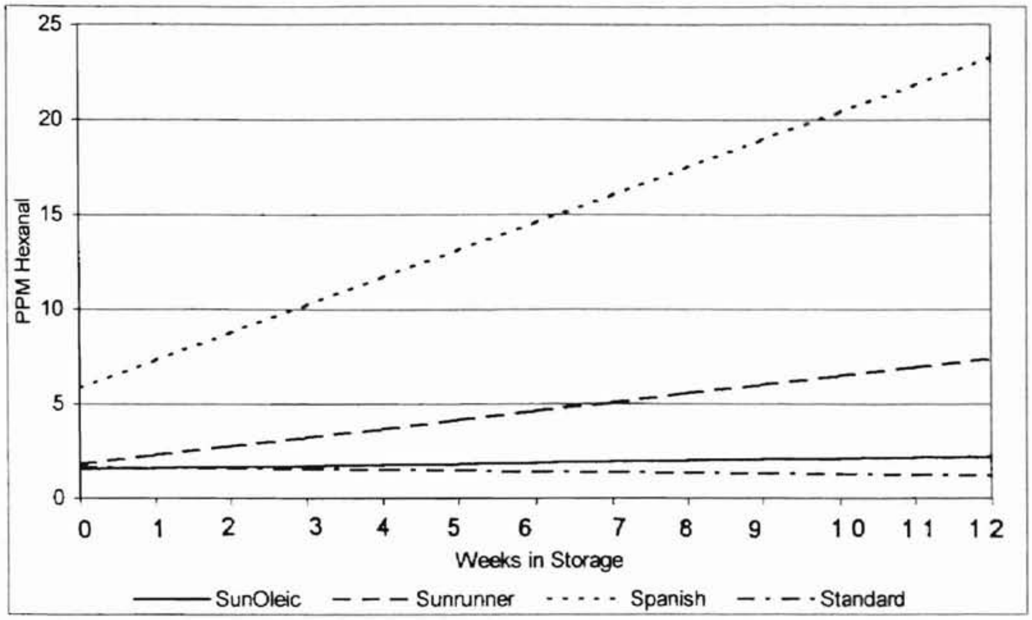

Figure 5. Hexanal vs. Weeks in Storage

Table 6. Least Squares Means and Standard Errors for hexanal at Week 6.

Varieties	SunOleic	Sunrunner	Spanco	Standard
HEXANAL	2.0469[a] *(0.7136)*	4.7042 *(0.7136)*	14.3177 *(0.7617)*	1.4203[a] *(0.8305)*

[a]Means having a common superscript are not significantly different at $\alpha = 0.05$.
**Values in parentheses are Standard Errors of the LSMeans.

Hexanal Discussion

As anticipated, the SunOleic production of hexanal, an organic byproduct of oxidation described by St. Angelo (1996), Hamilton (1983), and Fritsch and Gale (1977), proceeded more slowly than in either Sunrunner or Spanco. Spanco produced hexanal at a much higher rate than either SunOleic or Sunrunner, probably due to higher levels of linoleic acid since the rate at which hexanal is produced is dependent on formation of hydroperoxides from linoleic acid (Roozen, 1994b). Fritsch and Gale (1977) have shown hexanal production and hexanal levels reaching 5 – 10 PPM predict rancid odors and off-flavors in pecans and other nuts, and the results of this testing appear to agree. However, the sensory panelists detected and described off flavors in all three varieties, including SunOleic, after week 2 of storage, when the aromatics earthy and skunky emerged in all three varieties. These flavor changes were never reflected by significant hexanal increases in the SunOleic variety. Hexanal levels may be a predictor of some off flavors, but this researcher would not state that hexanal is necessarily indicative of the off flavors that developed in each variety. Other organic compounds created during oxidation may also cause the off flavors detected by the sensory panelists.

CHAPTER IV

HYPOTHESES TESTING AND RECOMMENDATIONS

The primary purpose of this study was to compare intensities of roasted peanut flavor attributes for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting and to repeatedly compare those flavor attributes over time by means of sensory evaluation of the roasted peanuts by a trained descriptive panel. The secondary purpose of this study was to compare consumer preferences for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting and to compare consumer preferences after aging the peanuts. And the final purpose of this study was to compare the hexanal levels for Sunrunner, SunOleic, and Spanco peanuts within 48 hours of initial roasting and to repeatedly compare those levels over time by means of gas chromatography.

Hypothesis Testing

Established statistical procedures were used in all portions of the analyses to test the hypotheses for this study. The alpha level was set at 0.05 for determining differences between means.

The first hypothesis (H_1) stated, "There will be no significant difference among the varieties of freshly roasted peanuts in the intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm." No significant differences were shown among the varieties for the following taste attributes: sweet or salt; the aromatics: cardboard, painty, fishy, earthy, or skunky; or for the chemical feeling factor mouthfilm ($p > 0.05$). Therefore, for these attributes, the researcher fails to reject H_1. However, as demonstrated in Table 1, significant differences were indicated in the freshly roasted peanuts for each of the remaining taste attributes: sour and bitter; the aromatics: peanutty, sweet aromatic, and woody; and for the chemical feeling factor astringency. Based on these results, the researcher rejected H_1.

The second hypothesis (H_2) stated, "There will be no significant difference as a result of aging over time among the varieties of peanuts in the intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm." No significant differences were indicated between any of the varieties for the following characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm ($p > 0.05$). As shown in Table 2, at 7-weeks in storage, there was a significant difference between SunOleic and Spanco ($p = 0.0017$) and between Sunrunner and Spanco ($p = 0.0024$) for the taste attribute sour. There were also significant differences between SunOleic and Spanco ($p = 0.0035$) and between Sunrunner and Spanco ($p = 0.0006$) for the aromatic cardboard (Figure 4). Based on these results, the researcher fails to reject H_2 for sweet, bitter, salt, peanutty, sweet aromatics, painty, fishy, woody, earthy, skunky, astringency and mouthfilm.

However, the researcher rejects H_2 for the taste sour and the aromatic cardboard.

The third hypothesis (H_3) stated, "There will be no significant difference among the varieties in the rate of increase over time in intensity of any of the following sensory characteristics: tastes, including sweet, sour, bitter, and salt; aromatics, including peanutty, sweet aromatics, cardboard, painty, fishy, woody, earthy and skunky; and chemical feeling factors, including astringency and mouthfilm." For several attributes (the tastes sweet and salt; the aromatics peanutty, sweet aromatic, and woody; and the chemical feeling factor astringency) there was no significant trend over time ($p > 0.05$). Although a clear trend was present, exhibited as parallel slopes for the aromatics cardboard, painty, fishy, earthy, skunky, and the chemical feeling factor mouthfilm, there was no significant difference in rate of increase ($p < 0.05$) (Figure 4 and Appendix B). Therefore, the researcher failed to reject H_3.

The fourth hypothesis (H_4) stated, "There will be no clear preference shown between the three varieties of freshly roasted peanuts in consumer preference testing." Consumer preference data indicated no significant difference ($p > 0.05$) between the three fresh roasted varieties, so the researcher failed to reject H_4.

The fifth hypothesis (H_5) stated, "There will be no clear preference shown between the three varieties of aged peanuts in consumer preference testing." Consumer preference data indicated no significant difference ($p > 0.05$) between the three varieties after aging, so the researcher failed to reject H_5.

The sixth hypothesis (H_6) stated, "There will be no significant difference in hexanal levels among the three varieties of freshly roasted peanuts." The results determined that the three varieties had equal amounts of hexanal initially ($p = 0.1014$), so the researcher failed to reject the hypothesis (H_6).

The seventh hypothesis (H_7) stated, "There will be no significant difference in hexanal levels among the three varieties of aged peanuts." There was no significant difference between the SunOleic and the Standard peanuts found at 6 weeks of storage ($p > 0.05$). However, as seen in Table 6, there was a significant difference between SunOleic and Sunrunner, SunOleic and Spanco, or between Sunrunner and Spanco at 6 weeks of storage, so the researcher rejected hypothesis H_7.

The eighth hypothesis (H_8) stated, "There will be no significant difference in the rates of increase in hexanal levels among the varieties of aged peanuts." Since, as shown in Figure 5, the production of hexanal as the peanuts aged in storage proceeded at rates that were significantly different among the varieties ($p \leq 0.0001$), the researcher rejects H_8.

Recommendations

This study demonstrated that a trained sensory panel has the ability to detect differences in aging peanut samples, even to the point of identifying new flavors that are formed during the aging process. It also showed that there are differences in the rates of aging and hexanal production for the three varieties of peanuts that were under examination in this study. Following are recommendations for additional research:

1. Test samples every 24 – 36 hours for the first 3 weeks, or until "rancid" attributes are perceived by the majority of the sensory panelists, in an effort to determine the point where autoxidation begins to increase dramatically in the samples. Blanch and chop the peanuts to uniform size prior to presenting as samples.

2. Blanch and chop the peanuts to a uniform chopped size prior to packaging for storage. Test samples every 24 – 36 hours until "rancid" attributes are perceived by the majority of the sensory panelists, in an effort to determine the point when autoxidation begins to cascade.
3. Study the textural changes of the varieties over time, as texture was found to change as well as flavor.
4. Utilize sensory evaluation score sheets that require the panelists to directly assign numerical values to results.
5. Set up consumer testing on a weekly basis as the peanuts age. Ask the consumers to note what characteristics or flavors are most influential in their decisions.
6. Study the training of sensory panelists to determine optimal length of training, effective methods of refreshing training from session to session, and the effects of cultural biases on scoring various flavor attributes.
7. Investigate the relationship between cultural background and perceived tastes among sensory panelists. See how cultural background affects perceived intensities of basic flavors and aromatics.
8. Investigate quantification of octane, pentane, pentanal or nonanal production as predictors of rancidity in aging peanuts.
9. Identify and quantify the specific flavor attributes associated with "rancidity" in peanuts.

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APPENDIX A

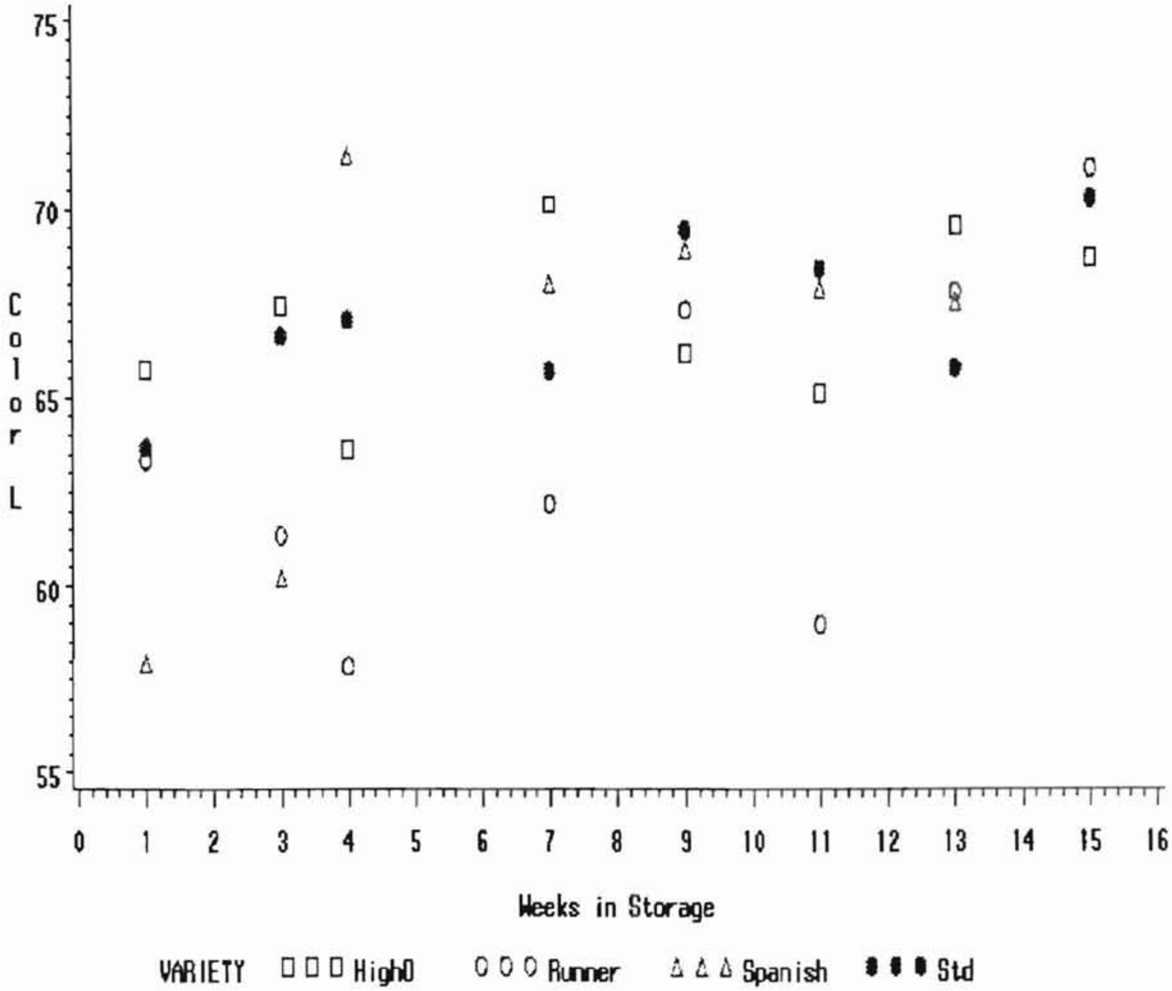
CIE L*a*b* COLOR ANALYSIS

CIE L*a*b* color analyses were performed to collect data regarding changes in color occurring over time. Testing was performed for each of the three varieties and a fresh standard at each test session. The data for each of the color values (L*, a*, and b*) were compared utilizing ANOVA and ANCOVA, and LSMeans were used to separate variety means when ANOVA tests were significant.

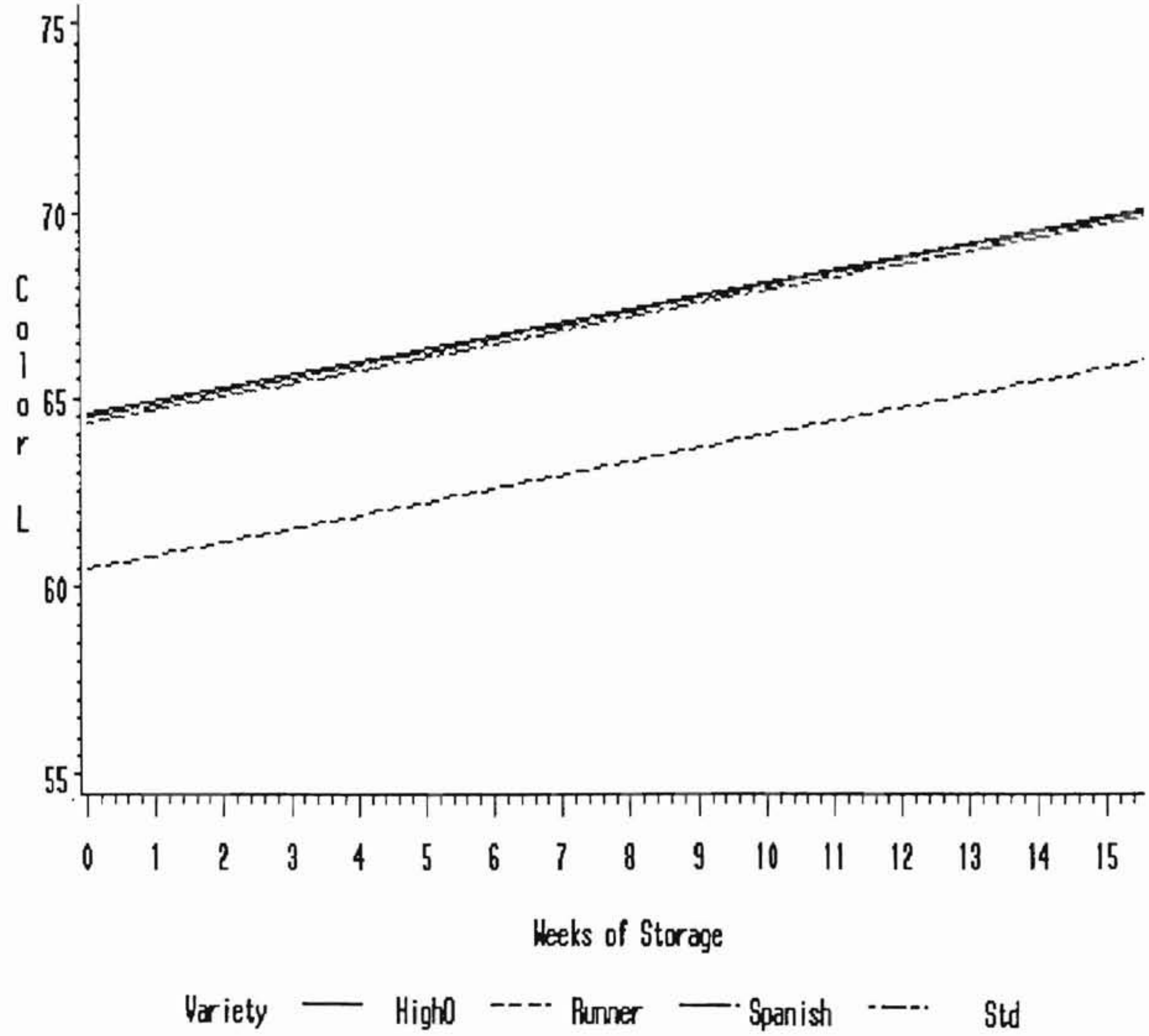
For all varieties, the a* and b* readings of the CIE L*a*b* color analysis do not exhibit a trend over time ($p = 0.05$), therefore ANOVA methods were used to test for differences for all varieties. ANOVA indicated no significant difference between SunOleic, Spanco, and a standard for the a* readings ($p = 0.0135$). For the b* readings, ANOVA indicated no significant difference between SunOleic, Sunrunner, and a standard ($p = 0.0107$).

The L* readings of the CIE L*a*b* color analysis exhibited a significant linear trend over time ($p = 0.009$). Therefore further analyses of the L* readings were done using ANCOVA techniques. The initial L* values of the three varieties were not equal ($p > 0.0176$) and as the peanuts aged in storage the L* values changed at the same rate in each of the varieties ($p > 0.0014$). The LSMeans indicated a significant difference between SunOleic and Sunrunner ($p = 0.0068$), between Sunrunner and Spanco ($p = 0.0096$), and between Sunrunner and a standard ($p = 0.0152$).

With regard to the a* readings, only the Sunrunner variety showed any significant difference from the other varieties, but only the Spanco variety showed significant differences from the others with regard to the b* readings. Although the initial L* readings were not equal, the values changed at the same rate in each of the varieties during aging. The L* readings of Sunrunner variety was significantly different from each of the other varieties at all times.



L* mean values.



Slope of L* for each variety.

L*a*b* CORRELATION DATA

SUNOLEIC

Correlation Matrix

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	1.0000	0.1634	0.3890	0.3205	-0.1392
HEXMN	0.1634	1.0000	-0.3728	0.2500	-0.2957
LMN	0.3890	-0.3728	1.0000	-0.2976	-0.1137
AMN	0.3205	0.2500	-0.2976	1.0000	0.6917
BMN	-0.1392	-0.2957	-0.1137	0.6917	1.0000

P-Values of the Correlations

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	0.0	0.6991	0.3409	0.4390	0.7424
HEXMN	0.6991	0.0	0.3630	0.5504	0.4771
LMN	0.3409	0.3630	0.0	0.4741	0.7886
AMN	0.4390	0.5504	0.4741	0.0	0.0573
BMN	0.7424	0.4771	0.7886	0.0573	0.0

SUNRUNNER

Correlation Matrix

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	1.0000	0.9808	0.7016	-0.2339	0.0455
HEXMN	0.9808	1.0000	0.7751	-0.1331	0.1592
LMN	0.7016	0.7751	1.0000	-0.0135	0.2755
AMN	-0.2339	-0.1331	-0.0135	1.0000	0.9019
BMN	0.0455	0.1592	0.2755	0.9019	1.0000

P-Values of the Correlations

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	0.0	0.0001	0.0524	0.5772	0.9147
HEXMN	0.0001	0.0	0.0239	0.7534	0.7066
LMN	0.0524	0.0239	0.0	0.9746	0.5090
AMN	0.5772	0.7534	0.9746	0.0	0.0022
BMN	0.9147	0.7066	0.5090	0.0022	0.0

SPANCO

Correlation Matrix

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	1.0000	0.9263	0.2193	-0.1275	-0.5120
HEXMN	0.9263	1.0000	-0.0907	-0.3048	-0.7154
LMN	0.2193	-0.0907	1.0000	-0.0359	0.3429
AMN	-0.1275	-0.3048	-0.0359	1.0000	0.7266
BMN	-0.5120	-0.7154	0.3429	0.7266	1.0000

P-Values of the Correlations

	WEEK	HEXMN	LMN	AMN	BMN
WEEK	0.0	0.0027	0.6366	0.7852	0.2401
HEXMN	0.0027	0.0	0.8466	0.5062	0.0707
LMN	0.6366	0.8466	0.0	0.9392	0.4515
AMN	0.7852	0.5062	0.9392	0.0	0.0643
BMN	0.2401	0.0707	0.4515	0.0643	0.0

APPENDIX B

MEANS DATA

OBS	DATE	WEEK	STOR	VARIETY	SWEETMN	SOURMN	BITTERMN	SALTMN
1		2	.	HighO	0.72353	2.41250	1.38824	0.34706
2		6	.	HighO	0.58571	1.10000	1.51429	0.46429
3		2	.	Runner	0.56250	1.38125	1.46250	0.40625
4		6	.	Runner	0.44000	1.16000	1.11333	0.36667
5		3	.	Spanish	1.45333	0.79333	0.66000	0.42667
6	24-Mar	0	-1	HighO	0.76471	1.18235	1.87778	0.38333
7	24-Mar	0	-1	Runner	0.85556	1.02778	1.12222	0.38889
8	24-Mar	0	-1	Spanish	0.88947	0.66316	0.68947	0.47368
9	24-Mar	.	-1	Std	.	.	.	.
10	31-Mar	1	0	HighO	0.63158	1.01579	1.33158	0.45263
11	31-Mar	1	0	Runner	0.56842	0.91579	1.14737	0.46316
12	31-Mar	1	0	Spanish	1.17059	0.74706	0.92353	0.30625
13	31-Mar	.	0	Std	.	.	.	.
14	7-Apr	.	1	HighO	.	.	.	.

OBS	PNUTMN	SWAROMMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN
1	3.52353	2.28235	2.76471	2.04706	1.27647	3.19412	0.00000
2	3.15333	2.00667	2.82000	1.92667	1.45714	2.38667	1.22667
3	4.46250	2.13125	2.93125	2.05625	1.06875	3.20625	0.00000
4	3.90667	2.47143	2.48667	1.38667	0.71429	2.60667	0.88000
5	2.78000	2.92000	2.06000	1.82000	1.26000	2.26000	0.00000
6	4.76667	2.05000	2.20000	1.42778	0.88889	3.78889	0.00000
7	5.46667	1.72778	1.94118	1.93889	1.17778	3.77222	0.00000
8	2.35263	2.36842	2.18421	1.09474	0.86842	2.20000	0.00000
9	.	.	.	.	.	.	.
10	3.21579	1.62632	2.76316	2.15789	1.29474	2.80000	0.00000
11	3.39474	1.76316	2.96316	1.84211	1.06316	2.84444	0.00000
12	3.05294	2.51765	1.93529	1.32353	0.72353	2.34118	0.00000
13	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.

OBS	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
1	0.00000	3.61176	4.28824	.	.	.	.
2	0.92000	3.28000	4.04000	.	.	.	.
3	0.00000	3.18000	4.40000	.	.	.	.
4	0.48000	2.93333	3.73333	.	.	.	.
5	0.00000	2.54667	3.81333	.	.	.	.
6	0.00000	4.00000	4.68333	3.0695	65.9017	5.51167	32.9133
7	0.00000	3.72778	4.22778	2.2836	61.2000	8.57500	35.6100
8	0.00000	2.66842	3.62105	1.6668	65.7550	5.55500	32.7667
9	.	.	.	.	.	.	.
10	0.00000	2.71579	3.95556	1.4998	65.1283	5.29167	33.5567
11	0.00000	3.02632	3.76111	2.1589	55.4600	7.09667	34.3633
12	0.00000	3.15882	3.70588	2.9816	69.2067	4.84167	32.2067
13	.	.	.	2.1994	.	.	.
14	.	.	.	2.0411	65.7367	6.62667	35.6233

OBS	DATE	WEEK	STOR	VARIETY	SWEETMN	SOURMN	BITTERMN	SALTMN
15	7-Apr	.	1	Runner	.	.	.	.
16	7-Apr	.	1	Spanish	.	.	.	.
17	7-Apr	.	1	Std	.	.	.	.
18	21-Apr	4	3	HighO	0.55333	1.20667	1.16000	0.57333
19	21-Apr	4	3	Runner	0.54667	1.18667	1.38667	0.50667
20	21-Apr	4	3	Spanish	1.36667	1.10667	0.83333	0.38000
21	21-Apr	.	3	Std	.	.	.	.
22	28-Apr	5	4	HighO	0.51250	1.51250	1.70000	0.35000
23	28-Apr	5	4	Runner	0.71250	1.47500	1.62500	0.32500
24	28-Apr	5	4	Spanish	1.19333	0.76000	0.72000	0.30000
25	28-Apr	.	4	Std	.	.	.	.
26	19-May	8	7	HighO	0.53750	1.51250	1.70000	0.36250
27	19-May	8	7	Runner	0.71250	1.47500	1.62500	0.32500
28	19-May	7	7	Spanish	0.85000	0.67500	1.17143	0.32857

OBS	PNUTMN	SWAROMMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN
15	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.
18	2.62667	2.16667	3.02667	2.11333	1.75333	2.96000	0.00000
19	3.36667	2.00000	2.83333	2.08000	1.68667	2.98000	0.00000
20	2.64667	4.07333	2.28667	1.44000	1.04667	1.90714	0.00000
21	.	.	.	.	.	.	.
22	3.57500	2.92500	2.97500	2.05000	1.93750	2.52500	1.61111
23	4.12500	2.57500	3.15000	2.07500	1.46250	2.42500	1.13000
24	3.49333	2.62000	2.08000	0.70667	0.58571	1.76000	0.40667
25	.	.	.	.	.	.	.
26	3.23750	2.80000	2.77500	2.02500	2.05000	2.72857	1.61111
27	4.12500	2.57500	3.11250	2.07500	1.46250	2.42500	1.25556
28	2.93750	2.56250	2.28750	1.66250	1.47500	1.88750	1.28889

OBS	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
15	.	.	.	2.3216	63.3600	6.88833	35.1117
16	.	.	.	6.5499	57.9650	6.76667	31.4517
17	.	.	.	1.2834	63.7000	5.76000	31.8617
18	0.00000	3.30667	3.67333	1.1905	67.4500	5.85000	32.6550
19	0.00000	3.32857	3.95000	2.9509	61.3700	4.15000	27.9567
20	0.00000	2.82667	3.96667	16.6904	60.2800	3.77000	27.6183
21	.	.	.	.	66.6617	6.07167	32.5717
22	1.18889	2.93750	4.81250	1.8635	63.6333	5.26667	32.0983
23	1.08000	3.43750	4.33750	3.4651	57.8583	7.81333	33.3133
24	0.44667	2.24000	3.09231	10.0344	71.4800	3.28500	29.9600
25	.	.	.	1.2685	67.1117	4.56167	30.8533
26	1.43333	3.18750	4.87143	1.3961	70.1917	2.31833	29.9250
27	1.20000	3.43750	4.33750	4.7891	62.2150	7.42500	34.2217
28	1.75556	2.71429	3.91667	11.9321	68.0550	7.05000	31.7767

OBS	DATE	WEEK	STOR	VARIETY	SWEETMN	SOURMN	BITTERMN	SALTMN
29	19-May	.	7	Std	.	.	.	.
30	2-Jun	10	9	HighO	0.51429	1.43333	1.21429	0.18571
31	2-Jun	10	9	Runner	0.74286	1.60000	1.58571	0.24286
32	2-Jun	9	9	Spanish	0.87143	1.34286	1.31429	0.24286
33	2-Jun	.	9	Std	.	.	.	.
34	16-Jun	12	11	HighO	0.81429	1.10000	1.61429	0.25714
35	16-Jun	12	11	Runner	0.41429	1.27143	1.47143	0.22857
36	16-Jun	11	11	Spanish	0.87143	0.88571	1.34286	0.34286
37	16-Jun	.	11	Std	.	.	.	.
38	30-Jun	.	13	HighO	.	.	.	.
39	30-Jun	.	13	Runner	.	.	.	.
40	30-Jun	.	13	Spanish	.	.	.	.
41	30-Jun	.	13	Std	.	.	.	.
42	15-Jul	16	15	HighO	0.61667	1.66667	1.66667	0.58333

OBS	PNUTMN	SWAROMMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN
29	.	.	.	.	.	.	.
30	2.08571	2.02857	3.37143	2.77143	1.44286	2.38571	1.41250
31	2.32857	2.47143	3.57143	2.68571	1.61429	2.80000	1.45000
32	2.35714	2.91429	3.50000	2.65714	1.70000	1.61429	1.33750
33	.	.	.	.	.	.	.
34	2.47143	1.85714	3.02857	1.90000	1.97143	2.54286	1.51250
35	2.81429	1.55714	3.41429	2.97143	2.22857	2.92857	1.73750
36	2.81429	1.78571	3.08571	3.40000	3.11429	2.75714	1.93750
37	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.
41	.	.	.	.	.	.	.
42	2.21667	2.25000	3.65000	1.73333	1.51667	3.21667	1.10000

OBS	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
29	.	.	.	1.3868	65.7417	5.44167	31.4200
30	0.77500	3.22857	4.34286	1.7486	66.2417	5.67833	32.1133
31	0.95000	3.64286	4.81429	6.2259	67.3717	6.85333	34.2250
32	0.93750	2.58571	4.41429	21.3170	69.0050	3.23667	28.2183
33	.	.	.	1.2016	69.5033	7.15333	32.8900
34	0.82500	3.07143	4.67143	3.9626	65.1850	5.87500	30.1950
35	1.32500	3.32857	4.91429	5.8357	58.9950	5.58833	31.0650
36	1.77500	3.01429	4.58571	26.9718	67.9100	4.82333	30.0050
37	.	.	.	1.1304	68.4750	5.11667	35.7217
38	.	.	.	1.8022	69.6583	5.49333	32.1517
39	.	.	.	10.4026	67.8717	7.20833	36.1283
40	.	.	.	19.9552	67.5867	5.13167	29.3150
41	.	.	.	1.1106	65.8400	5.24333	34.9600
42	0.91250	2.73333	4.33333	1.9252	68.7800	7.50167	34.2767

OBS	DATE	WEEK	STOR	VARIETY	SWEETMN	SOURMN	BITTERMN	SALTMN
43	15-Jul	16	15	Runner	0.33333	1.65000	1.60000	0.43333
44	15-Jul	15	15	Spanish	0.60000	1.83333	1.65000	0.36667
45	15-Jul	.	15	Std	.	.	.	.
46		24	23	HighO	1.37143	1.87143	2.28571	0.67143
47		24	23	Runner	0.78571	2.68571	2.64286	0.28571
48		23	23	Spanish	1.42857	1.77143	1.40000	0.32857

OBS	PNUTMN	SWAROMMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN
43	2.76667	2.16667	3.55000	2.88333	2.21667	3.78333	1.40000
44	1.85000	2.08333	3.46667	3.28333	2.60000	3.73333	1.18750
45	.	.	.	.	.	.	.
46	3.08571	2.27143	4.17143	3.28571	2.82857	3.27143	3.07143
47	2.08571	1.55714	4.01429	3.68571	2.57143	3.64286	2.41429
48	2.70000	3.40000	3.42857	3.02857	1.61429	3.20000	2.07143

OBS	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
43	0.95000	3.48333	4.85000	7.4917	71.1617	6.92667	35.3600
44	1.62500	3.71667	4.75000	.	.	.	.
45	.	.	.	1.3147	70.3683	3.56333	29.3917
46	2.41429	3.68333	4.21667	.	.	.	.
47	2.60000	3.82857	4.28571	.	.	.	.
48	1.47143	3.07143	4.17143	.	.	.	.

CORRELATION DATA FOR SUNOLEIC

Correlation Matrix

	STOR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SWAROMMN	CROBROWN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STOR	1.0000	-0.0282	0.5879	0.0395	-0.0673	-0.7603	0.1140	0.8305	0.1379	0.4390	-0.3228	0.6786	0.6202	-0.4592	0.1872	-0.1654	0.3890	0.3205	-0.1392
SWEETMN	-0.0282	1.0000	-0.5768	0.4250	-0.0950	0.2801	-0.5633	-0.3890	-0.6299	0.3147	0.4387	-0.2451	-0.3496	0.3191	0.1753	0.8853	0.2306	0.2672	-0.0817
SOURMN	0.5879	-0.5768	1.0000	0.2641	0.0920	-0.2586	0.7260	0.5803	0.0760	0.3025	-0.0964	0.6126	0.7331	-0.2320	0.3710	-0.3479	0.4587	0.0011	0.0527
BITTERMN	0.0395	0.4250	0.2641	1.0000	-0.0583	0.8101	0.4056	-0.3904	-0.7758	-0.0552	0.4662	0.2541	0.3622	0.2746	0.8136	0.5044	0.0341	-0.1569	-0.1825
SALTMN	-0.0673	-0.0950	0.0920	-0.0583	1.0000	0.0100	0.0077	0.1168	0.4368	-0.1174	0.5224	-0.5479	-0.3515	0.2072	-0.5511	-0.4215	0.3695	0.3210	0.6176
PNUTMN	-0.7603	0.2801	-0.2586	0.8101	0.0100	1.0000	0.1749	-0.9033	-0.6033	-0.4356	0.6002	-0.3854	-0.2730	0.6093	0.3736	0.1877	-0.2543	-0.3340	0.0314
SWAROMMN	0.1140	-0.5633	0.7260	0.4056	0.0077	0.1749	1.0000	0.0473	-0.0590	0.5535	-0.1568	0.5587	0.7219	-0.0175	0.5487	-0.3214	0.2380	-0.4516	-0.3250
CROBROWN	0.8305	-0.3890	0.5803	-0.3904	0.1168	-0.9033	0.0473	1.0000	0.4564	0.3620	-0.4641	0.4619	0.3981	-0.6649	-0.2404	-0.2401	0.2218	0.4907	0.1962
PAINTMN	0.1379	-0.6299	0.0760	-0.7758	0.4368	-0.6033	-0.0590	0.4564	1.0000	0.2485	-0.7960	0.2917	0.1638	-0.3328	-0.2940	-0.4646	-0.0875	-0.1312	-0.1534
FISHMN	0.4390	0.3147	0.3025	-0.0552	-0.1174	-0.4356	0.5535	0.3620	0.2485	1.0000	-0.6865	0.6866	0.7033	-0.4478	0.2425	-0.1056	0.1752	-0.3626	-0.6668
WOODMN	-0.3228	0.4387	-0.0964	0.4662	0.5224	0.6002	-0.1568	-0.4641	-0.7960	-0.6865	1.0000	-0.6407	-0.5115	0.5645	-0.0491	0.1756	0.2117	0.2333	0.4907
EARTHMN	0.6786	-0.2451	0.6126	0.2541	-0.5479	-0.3854	0.5587	0.4619	0.2917	0.6866	-0.6407	1.0000	0.9514	-0.3331	0.6760	0.1461	0.0889	-0.2365	-0.5923
SKUNKMN	0.6202	-0.3496	0.7331	0.3622	-0.3515	-0.2730	0.7219	0.3981	0.1638	0.7033	-0.5115	0.9514	1.0000	-0.3492	0.6960	-0.0244	0.2750	-0.3670	-0.5432
ASTRINMN	-0.4592	0.3191	-0.2320	0.2746	0.2072	0.6093	-0.0175	-0.6649	-0.3328	-0.4478	0.5645	-0.3331	-0.3492	1.0000	0.2066	0.3187	0.0193	-0.1663	0.1581
MOUTHMN	0.1872	0.1753	0.3710	0.8136	-0.5511	0.3736	0.5487	-0.2404	-0.2940	0.2425	-0.0491	0.6760	0.6960	0.2066	1.0000	0.4629	-0.0306	-0.4151	-0.5574
HEXMN	-0.1654	0.8853	-0.3479	0.5044	-0.4215	0.1877	-0.3214	-0.2401	-0.4646	-0.1056	0.1756	0.1461	-0.0244	0.3187	0.4629	1.0000	-0.3728	0.2500	-0.2967
LMN	0.3890	0.2306	0.4587	0.0341	0.3695	-0.2543	0.2380	0.2218	-0.0875	0.1752	0.2117	0.0889	0.2750	0.0193	-0.0306	-0.3728	1.0000	0.2976	-0.1137
AMN	0.3205	0.2672	0.0011	-0.1569	0.3210	-0.3340	-0.4516	0.4907	-0.1312	-0.3626	0.2333	-0.2365	-0.3670	-0.1663	-0.4151	0.2500	0.2976	1.0000	0.6917
BMN	-0.1392	-0.0817	0.0527	-0.1825	0.6176	0.0314	-0.3250	0.1962	-0.1534	-0.6668	0.4907	-0.5923	-0.5432	0.1581	-0.5574	-0.2967	-0.1137	0.6917	1.0000

P Values of the Correlations

	STOR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SWARDMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STOR	0.0	0.9472	0.1254	0.9260	0.8742	0.0285	0.7881	0.0107	0.7447	0.2765	0.4355	0.0654	0.1009	0.2524	0.8570	0.8991	0.3409	0.4390	0.7424
SWEETMN	0.9472	0.0	0.1344	0.2938	0.8229	0.5017	0.1460	0.3408	0.0942	0.4477	0.2769	0.5585	0.3959	0.4410	0.6780	0.0035	0.5827	0.5223	0.8474
SOURMN	0.1254	0.1344	0.0	0.5274	0.8284	0.5363	0.0414	0.1486	0.8560	0.4665	0.8204	0.1064	0.0385	0.5803	0.3656	0.3984	0.2530	0.9980	0.9014
BITTERMN	0.9260	0.2938	0.5274	0.0	0.8947	0.1082	0.3188	0.3390	0.0237	0.8968	0.2442	0.5438	0.3780	0.5103	0.0140	0.2025	0.9361	0.7105	0.7006
SALTMN	0.8742	0.8229	0.8284	0.8947	0.0	0.9812	0.9856	0.7829	0.2792	0.7818	0.1841	0.1598	0.3932	0.8224	0.1568	0.2984	0.3677	0.4383	0.1027
PNUTMN	0.0285	0.5017	0.5363	0.1082	0.9812	0.0	0.8787	0.0021	0.1134	0.2907	0.1157	0.3458	0.5130	0.1088	0.3620	0.6562	0.5433	0.4187	0.9411
SWARDMN	0.7881	0.1460	0.0414	0.3188	0.9856	0.8787	0.0	0.9114	0.8896	0.1546	0.7107	0.1500	0.0432	0.9672	0.1590	0.4376	0.5703	0.2614	0.4321
CRDBRDMN	0.0107	0.3408	0.1486	0.3390	0.7829	0.0021	0.9114	0.0	0.2557	0.3782	0.2467	0.2492	0.3287	0.0720	0.5663	0.5668	0.5975	0.2170	0.6414
PAINTMN	0.7447	0.0942	0.8560	0.0237	0.2792	0.1134	0.8896	0.2557	0.0	0.5529	0.0181	0.4833	0.6984	0.4206	0.4797	0.2461	0.8367	0.7568	0.7169
FISHMN	0.2765	0.4477	0.4665	0.8968	0.7818	0.2907	0.1546	0.3782	0.5529	0.0	0.0601	0.0600	0.0516	0.2659	0.5626	0.8030	0.6782	0.3771	0.0709
WOODMN	0.4355	0.2769	0.8204	0.2442	0.1841	0.1157	0.7107	0.2467	0.0181	0.0601	0.0	0.0870	0.1951	0.1449	0.9082	0.6775	0.6147	0.5782	0.2169
EARTHMN	0.0654	0.5585	0.1064	0.5438	0.1598	0.3458	0.1500	0.2492	0.4833	0.0600	0.0870	0.0	0.0003	0.4200	0.0657	0.7300	0.8342	0.5694	0.1218
SKUNKMN	0.1009	0.3959	0.0385	0.3780	0.3932	0.5130	0.0432	0.3287	0.6984	0.0516	0.1951	0.0003	0.0	0.3965	0.0642	0.9542	0.5098	0.3712	0.1641
ASTRINMN	0.2524	0.4410	0.5803	0.5103	0.8224	0.1088	0.9672	0.0720	0.4206	0.2659	0.1449	0.4200	0.3965	0.0	0.8235	0.4418	0.9639	0.6587	0.7067
MOUTHMN	0.8570	0.6780	0.3656	0.0140	0.1568	0.3620	0.1590	0.5663	0.4797	0.5626	0.9082	0.0657	0.0642	0.8235	0.0	0.2481	0.9426	0.3065	0.1512
HEXMN	0.8991	0.0035	0.3984	0.2025	0.2984	0.6562	0.4376	0.5668	0.2461	0.8030	0.6775	0.7300	0.9542	0.4418	0.2481	0.0	0.3630	0.5504	0.4771
LMN	0.3409	0.5827	0.2530	0.9361	0.3677	0.5433	0.5703	0.5975	0.8367	0.6782	0.6147	0.8342	0.5098	0.9639	0.9426	0.3630	0.0	0.4741	0.7886
AMN	0.4390	0.5223	0.9980	0.7105	0.4383	0.4187	0.2614	0.2170	0.7568	0.3771	0.5782	0.5694	0.3712	0.6587	0.3065	0.5504	0.4741	0.0	0.0573
BMN	0.7424	0.8474	0.9014	0.7006	0.1027	0.9411	0.4321	0.6414	0.7169	0.0709	0.2169	0.1218	0.1641	0.7067	0.1512	0.4771	0.7886	0.0573	0.0

CORRELATION DATA FOR SUNRUNNER

Correlation Matrix

	STDR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SWARDMN	CRDBRDMN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STDR	1.0000	0.6495	0.7975	0.7408	0.4021	0.6931	0.2200	0.8165	0.9114	0.8816	0.1107	0.8574	0.7563	0.1505	0.8627	0.9808	0.7016	-0.2339	0.0455
SWEETMN	-0.6495	1.0000	0.1784	-0.2149	0.1898	0.6476	0.3252	-0.5788	-0.8137	-0.7858	-0.2295	-0.3212	-0.2303	0.4949	-0.3201	-0.5220	-0.2399	0.5698	0.2984
SOURMN	0.7975	0.1784	1.0000	0.9364	0.4363	-0.4562	0.7324	0.7119	0.8100	0.5746	-0.1336	0.8012	0.7870	0.4337	0.7311	0.8300	0.7321	0.0326	0.1865
BITTERMN	0.7408	-0.2149	0.9364	1.0000	-0.4716	0.4552	0.7515	0.7593	0.5257	0.5675	-0.4122	0.8231	0.8493	0.2160	0.6238	0.7271	0.4859	-0.1080	-0.0511
SALTMN	-0.4021	-0.1898	-0.4363	0.4716	1.0000	0.2177	-0.2119	0.4047	-0.5175	-0.2793	0.3593	-0.7764	-0.7716	-0.3697	-0.7099	-0.4706	-0.0590	-0.2079	-0.1666
PNUTMN	0.6931	0.6476	-0.4562	-0.4552	0.2177	1.0000	0.0713	-0.8839	0.7135	-0.8191	0.1433	-0.5304	-0.3812	0.2886	-0.4842	-0.6793	0.3955	0.5725	0.2602
SWARDMN	0.2200	0.3252	0.7324	0.7515	-0.2119	-0.0713	1.0000	0.3802	-0.0672	-0.0794	-0.5103	0.3752	0.4564	0.2969	0.1385	0.2722	0.3405	0.2489	0.2003
CRDBRDMN	0.8165	-0.5788	0.7119	0.7593	-0.4047	0.6839	0.3802	1.0000	0.7111	0.6419	-0.3443	0.7883	0.7162	-0.2160	0.6075	0.7918	0.3964	-0.3217	-0.0775
PAINTMN	0.9114	-0.8137	0.8100	0.5257	-0.5175	-0.7135	0.0672	0.7111	1.0000	0.9054	0.2333	0.7988	0.6476	0.2099	0.9223	0.9093	0.6013	-0.2958	0.0381
FISHMN	0.8816	0.7858	0.5746	0.5675	-0.2793	-0.8191	-0.0794	-0.6419	0.9054	1.0000	0.2214	0.6962	0.5956	0.0821	0.7780	0.8197	0.5333	-0.4975	-0.2934
WOODMN	0.1107	0.2295	-0.1336	-0.4122	0.3593	0.1433	0.5103	0.3443	0.2333	0.2214	1.0000	-0.2387	-0.3830	0.3709	0.1773	0.1382	0.4770	0.1208	0.2938
EARTHMN	0.8574	0.3212	0.8012	0.8231	-0.7764	-0.5304	0.3752	0.7883	0.7988	0.6962	-0.2387	1.0000	0.9701	0.2240	0.8896	0.8831	0.4257	0.0076	0.1324
SKUNKMN	0.7563	0.2303	0.7870	0.8493	0.7716	0.3812	0.4564	0.7162	0.6476	0.5956	-0.3830	0.9701	1.0000	0.1770	0.7803	0.7445	0.2812	0.0698	0.1139
ASTRINMN	0.1505	0.4949	0.4337	0.2160	0.3697	0.2886	0.2969	0.2160	0.2099	0.0821	0.3709	0.2240	0.1770	1.0000	0.4849	0.2778	0.5713	0.4046	0.3493
MOUTHMN	0.8627	0.3201	0.7311	0.6238	0.7099	0.4842	0.1385	0.6075	0.9223	0.7780	0.1773	0.8896	0.7803	0.4849	1.0000	0.9012	0.6290	0.0124	0.1850
HEXMN	0.9808	0.5220	0.8300	0.7271	0.4706	0.6793	0.2722	0.7918	0.9093	0.8197	0.1382	0.8831	0.7445	0.2778	0.9012	1.0000	0.7751	-0.1331	0.1592
LMN	0.7016	-0.2399	0.7321	0.4859	0.0590	-0.3955	0.3405	0.3964	0.6013	0.5333	0.4770	0.4257	0.2812	0.5713	0.6290	0.7751	1.0000	-0.0135	0.2735
AMN	0.2339	0.5698	0.0326	0.1080	0.2079	0.5725	0.2489	0.3217	-0.2958	0.4975	0.1208	0.0076	0.0698	0.4046	0.0124	-0.1331	-0.0135	1.0000	0.9019
BMN	0.0455	0.2984	0.1865	-0.0511	-0.1666	0.2602	0.2003	0.0775	-0.0381	-0.2934	0.2938	0.1324	0.1139	0.3493	0.1850	0.1592	0.2735	0.9019	1.0000

P-Values of the Correlations

	STOR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SWARDMN	CROBROWN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STOR	0.0	0.0813	0.0177	0.0355	0.3234	0.0566	0.8006	0.0134	0.0016	0.0029	0.7942	0.0065	0.0299	0.7221	0.0058	0.0001	0.0524	0.5772	0.9147
SWEETMN	0.0813	0.0	0.6725	0.6093	0.6525	0.0625	0.4318	0.1327	0.1056	0.0268	0.5846	0.4379	0.5832	0.2124	0.4395	0.1845	0.5672	0.1405	0.4728
SOURMN	0.0177	0.6725	0.0	0.0006	0.2798	0.2559	0.0388	0.0476	0.1083	0.1363	0.7524	0.0168	0.0264	0.2831	0.0394	0.0108	0.0389	0.9588	0.6935
BITTERMN	0.0355	0.6093	0.0006	0.0	0.2381	0.2571	0.0316	0.0289	0.1809	0.1423	0.3102	0.0121	0.0078	0.6040	0.0985	0.0410	0.2222	0.7990	0.9043
SALTMN	0.3234	0.6525	0.2798	0.2381	0.0	0.6046	0.8144	0.3199	0.1890	0.5030	0.3820	0.0235	0.0249	0.3674	0.0485	0.2393	0.8896	0.6213	0.6934
PNUTMN	0.0566	0.0625	0.2559	0.2571	0.6046	0.0	0.8867	0.0036	0.0469	0.1017	0.7349	0.1763	0.3515	0.4881	0.2241	0.0639	0.3321	0.1381	0.5337
SWARDMN	0.8006	0.4318	0.0388	0.0316	0.8144	0.8867	0.0	0.3528	0.8743	0.8517	0.1963	0.3597	0.2556	0.4752	0.7419	0.5142	0.4092	0.5523	0.8344
CROBROWN	0.0134	0.1327	0.0476	0.0289	0.3199	0.0036	0.3528	0.0	0.0480	0.0862	0.4037	0.0201	0.0457	0.6074	0.1102	0.0192	0.3310	0.4371	0.8552
PAINTMN	0.0016	0.1056	0.1083	0.1809	0.1890	0.0469	0.8743	0.0480	0.0	0.0020	0.5782	0.0174	0.0825	0.6179	0.0011	0.0017	0.1148	0.4769	0.9323
FISHMN	0.0029	0.0268	0.1363	0.1423	0.5030	0.1017	0.8517	0.0862	0.0020	0.0	0.5982	0.0551	0.1193	0.8468	0.0230	0.0127	0.1735	0.2097	0.4807
WOODMN	0.7942	0.5846	0.7524	0.3102	0.3820	0.7349	0.1963	0.4037	0.5782	0.5982	0.0	0.5692	0.3490	0.3657	0.6745	0.7441	0.2320	0.7756	0.4800
EARTHMN	0.0065	0.4379	0.0168	0.0121	0.0235	0.1763	0.3597	0.0201	0.0174	0.0551	0.5692	0.0	0.0001	0.5938	0.0031	0.0058	0.2929	0.9857	0.7546
SKUNKMN	0.0299	0.5832	0.0264	0.0078	0.0249	0.3515	0.2556	0.0457	0.0825	0.1193	0.3490	0.0001	0.0	0.8749	0.0223	0.0341	0.4999	0.8696	0.7883
ASTRINMN	0.7221	0.2124	0.2831	0.6040	0.3674	0.4881	0.4752	0.6074	0.6179	0.8468	0.3657	0.5938	0.8749	0.0	0.2233	0.5056	0.1391	0.3201	0.3965
MOUTHMN	0.0058	0.4395	0.0394	0.0985	0.0485	0.2241	0.7419	0.1102	0.0011	0.0230	0.6745	0.0031	0.0223	0.2233	0.0	0.0022	0.0948	0.9768	0.6594
HEXMN	0.0001	0.1845	0.0108	0.0410	0.2393	0.0639	0.5142	0.0192	0.0017	0.0127	0.7441	0.0058	0.0341	0.5056	0.0022	0.0	0.0239	0.7534	0.7066
LMN	0.0524	0.5672	0.0389	0.2222	0.8896	0.3321	0.4092	0.3310	0.1148	0.1735	0.2320	0.2929	0.4999	0.1391	0.0948	0.0239	0.0	0.9746	0.5090
AMN	0.5772	0.1405	0.9588	0.7990	0.6213	0.1381	0.5523	0.4371	0.4769	0.2097	0.7756	0.9857	0.8696	0.3201	0.9768	0.7534	0.9746	0.0	0.0022
BMN	0.9147	0.4728	0.6933	0.9043	0.6934	0.5337	0.8344	0.8552	0.9323	0.4807	0.4800	0.7546	0.7883	0.3965	0.6594	0.7066	0.5090	0.0022	0.0

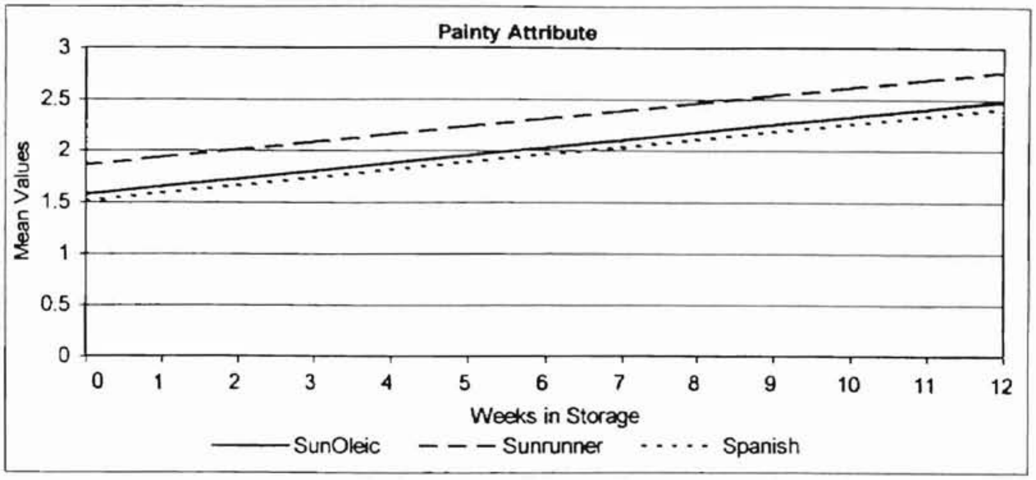
CORRELATION DATA FOR SPANCO

Correlation Matrix

	STOR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SWAROMMN	CROBROWN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRIMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STOR	1.0000	-0.4681	0.4544	0.8772	-0.5443	-0.0332	0.2482	0.8042	0.8276	0.8358	0.0404	0.9524	0.8715	-0.0437	0.7040	0.9135	0.2256	-0.0830	0.4791
SWEETMN	-0.4681	1.0000	0.0976	-0.5812	0.0045	0.4003	0.8907	-0.5331	-0.5340	-0.5540	-0.1815	-0.6846	-0.6711	0.0054	-0.4626	-0.2062	-0.3791	-0.4970	-0.3723
SOURMN	0.4544	0.0976	1.0000	0.4429	-0.4801	-0.4668	0.5062	0.7409	0.4873	0.2691	-0.3901	0.2483	0.0133	-0.0552	0.5722	0.8458	-0.2527	-0.6715	-0.8688
BITTERMN	0.8772	-0.5812	0.4429	1.0000	-0.5486	0.2390	-0.3112	0.9058	0.9083	0.8336	0.1756	0.9052	0.8177	0.3176	0.8655	0.7652	0.2049	0.1148	-0.2662
SALTMN	-0.5443	0.0045	-0.4801	-0.5486	1.0000	0.3433	-0.0064	-0.4258	-0.3062	-0.1450	0.3638	-0.4331	-0.3422	0.1213	-0.2008	-0.4111	-0.5711	0.4080	0.4118
PNUTMN	-0.0332	0.4003	-0.4668	0.2390	0.3433	1.0000	-0.1708	-0.5121	-0.3842	-0.2551	0.0075	-0.0742	0.0631	-0.2111	-0.5834	-0.1651	0.5187	-0.0629	0.1304
SWAROMMN	-0.2482	0.8907	0.5062	-0.3112	-0.0064	-0.1708	1.0000	0.1414	-0.3404	-0.4476	-0.6018	-0.4924	-0.4926	0.1382	-0.1117	0.0013	0.6737	0.3867	-0.8243
CROBROWN	0.8042	-0.5331	0.7409	0.9058	-0.4258	-0.5121	0.1414	1.0000	0.8642	0.7409	-0.0322	0.7828	0.5418	-0.0096	0.8213	0.8170	0.0857	-0.3043	-0.5351
PAINTMN	0.8276	-0.5340	0.4873	0.9083	-0.3062	-0.3842	-0.3404	0.8642	1.0000	0.9509	0.4087	0.8492	0.8900	0.3997	0.9453	0.8434	0.0248	-0.0237	-0.3338
FISHMN	0.8358	-0.5540	0.2691	0.8336	-0.1450	-0.2551	-0.4476	0.7409	0.9509	1.0000	0.5280	0.8831	0.7857	0.3544	0.8571	0.8312	0.0132	0.1208	-0.2294
WOODMN	0.0404	-0.1815	-0.3901	0.1756	0.3638	0.0075	-0.6018	-0.0322	0.4087	0.5280	1.0000	0.1997	0.1849	0.7209	0.3254	0.0976	-0.0392	0.3283	0.3974
EARTHMN	0.9524	-0.6846	0.2483	0.9052	-0.4331	-0.0742	-0.4924	0.7828	0.8492	0.8831	0.1997	1.0000	0.9474	0.0477	0.7098	0.7900	0.3333	0.1482	-0.2008
SKUNKMN	0.8715	-0.6711	0.0133	0.8177	-0.3422	0.0631	-0.4926	0.5418	0.8900	0.7857	0.1849	0.9474	1.0000	0.0374	0.5663	0.8489	0.3175	0.3907	-0.0369
ASTRIMN	-0.0437	0.0054	-0.0552	0.3176	0.1213	-0.2111	0.1382	-0.0096	0.3997	0.3544	0.7209	0.0477	0.0374	1.0000	0.5072	0.0595	-0.2972	0.3352	0.2134
MOUTHMN	0.7040	-0.4626	0.5722	0.8655	-0.2008	-0.5834	-0.1117	0.8213	0.9453	0.8571	0.3254	0.7098	0.5663	0.5072	1.0000	0.7735	-0.2304	0.0451	-0.3707
HEXMN	0.9135	-0.2062	0.8458	0.7652	-0.4111	0.1651	0.0013	0.8170	0.8434	0.8312	0.0976	0.7900	0.8489	0.0595	0.7735	1.0000	-0.0907	0.3048	0.7154
LMN	0.2256	-0.3791	-0.2527	0.2049	-0.5711	0.5187	0.6737	0.0857	0.0248	0.0132	-0.0392	0.3333	0.3175	-0.2972	-0.2304	-0.0907	1.0000	-0.0359	0.3429
AMN	-0.0830	-0.4970	-0.6715	0.1148	0.4080	-0.0629	0.3867	-0.3043	-0.0237	0.1208	0.3283	0.1482	0.3907	0.3352	0.0451	0.3048	-0.0359	1.0000	0.7266
BMN	0.4791	-0.3723	-0.8688	-0.2662	0.4118	0.1304	-0.8243	-0.5351	-0.3338	-0.2294	0.3974	-0.2008	-0.0369	0.2134	-0.3707	[illegible]	0.3429	0.7266	1.0000

P-Values of the Correlations

	STOR	SWEETMN	SOURMN	BITTERMN	SALTMN	PNUTMN	SMAROMMN	CROBROMN	PAINTMN	FISHMN	WOODMN	EARTHMN	SKUNKMN	ASTRINMN	MOUTHMN	HEXMN	LMN	AMN	BMN
STOR	0.0	0.2895	0.3057	0.0095	0.2065	0.9437	0.5916	0.0292	0.0218	0.0192	0.9315	0.0009	0.0106	0.9259	0.0775	0.0040	0.8267	0.8595	0.2787
SWEETMN	0.2895	0.0	0.8351	0.1621	0.9923	0.3736	0.0858	0.2179	0.2170	0.1969	0.6969	0.0897	0.0988	0.9908	0.2959	0.6573	0.4017	0.2565	0.4109
SOURMN	0.3057	0.8351	0.0	0.3196	0.2756	0.2910	0.2464	0.0568	0.2673	0.5596	0.3889	0.5913	0.9775	0.9064	0.1795	0.1172	0.5846	0.0985	0.0111
BITTERMN	0.0095	0.1621	0.3196	0.0	0.2022	0.8058	0.4969	0.0287	0.0048	0.0198	0.7064	0.0051	0.0248	0.4877	0.0118	0.0450	0.8594	0.8064	0.5639
SALTMN	0.2065	0.9923	0.2756	0.2022	0.0	0.4510	0.9892	0.3408	0.5042	0.7565	0.4225	0.3318	0.4524	0.7956	0.6659	0.3595	0.1805	0.3836	0.3587
PNUTMN	0.9437	0.3736	0.2910	0.8058	0.4510	0.0	0.7142	0.2400	0.3948	0.5609	0.9472	0.8744	0.8930	0.8495	0.1691	0.7235	0.2329	0.8934	0.7857
SMAROMMN	0.5916	0.0858	0.2464	0.4969	0.9892	0.7142	0.0	0.7623	0.4549	0.3139	0.1529	0.2616	0.2614	0.7675	0.8118	0.9978	0.0970	0.3914	0.1339
CROBROMN	0.0292	0.2179	0.0568	0.0287	0.3408	0.2400	0.7623	0.0	0.0121	0.0568	0.9453	0.0481	0.2090	0.9837	0.0235	0.0249	0.8551	0.5070	0.2158
PAINTMN	0.0218	0.2170	0.2673	0.0048	0.5042	0.3948	0.4549	0.0121	0.0	0.0010	0.3627	0.0156	0.0862	0.3743	0.0013	0.0171	0.9582	0.9598	0.4644
FISHMN	0.0192	0.1969	0.5596	0.0198	0.7565	0.5609	0.3139	0.0568	0.0010	0.0	0.2231	0.0084	0.0362	0.4354	0.0137	0.0208	0.9776	0.7965	0.8207
WOODMN	0.9315	0.6969	0.3889	0.7064	0.4225	0.9472	0.1529	0.9453	0.3627	0.2231	0.0	0.8878	0.8915	0.0675	0.4764	0.8351	0.9335	0.4721	0.3774
EARTHMN	0.0009	0.0897	0.5913	0.0051	0.3318	0.8744	0.2616	0.0481	0.0156	0.0084	0.8878	0.0	0.0012	0.9191	0.0740	0.0345	0.4651	0.7511	0.6659
SKUNKMN	0.0106	0.0988	0.9775	0.0248	0.4524	0.8930	0.2614	0.2090	0.0862	0.0362	0.8915	0.0012	0.0	0.9365	0.1851	0.1148	0.4878	0.3862	0.9375
ASTRINMN	0.9259	0.9908	0.9064	0.4877	0.7956	0.8495	0.7675	0.9837	0.3743	0.4354	0.0675	0.9191	0.9365	0.0	0.2453	0.8991	0.5175	0.4823	0.8458
MOUTHMN	0.0775	0.2959	0.1795	0.0118	0.6659	0.1691	0.8118	0.0235	0.0013	0.0137	0.4764	0.0740	0.1851	0.2453	0.0	0.0413	0.8191	0.9234	0.4130
HEXMN	0.0040	0.6573	0.1172	0.0450	0.3595	0.7235	0.9978	0.0249	0.0171	0.0208	0.8351	0.0345	0.1148	0.8991	0.0413	0.0	0.8486	0.5062	0.0707
LMN	0.8267	0.4017	0.5846	0.8594	0.1805	0.2329	0.0970	0.8551	0.9582	0.9776	0.9335	0.4651	0.4878	0.5175	0.8191	0.8486	0.0	0.9392	0.4515
AMN	0.8595	0.2565	0.0985	0.8064	0.3836	0.8934	0.3914	0.5070	0.9598	0.7965	0.4721	0.7511	0.3862	0.4823	0.9234	0.5062	0.9392	0.0	0.0643
BMN	0.2787	0.4109	0.0111	0.5639	0.3587	0.7857	0.1339	0.2158	0.4644	0.8207	0.3774	0.6659	0.9375	0.8458	0.4130	0.0707	0.4515	0.0643	0.0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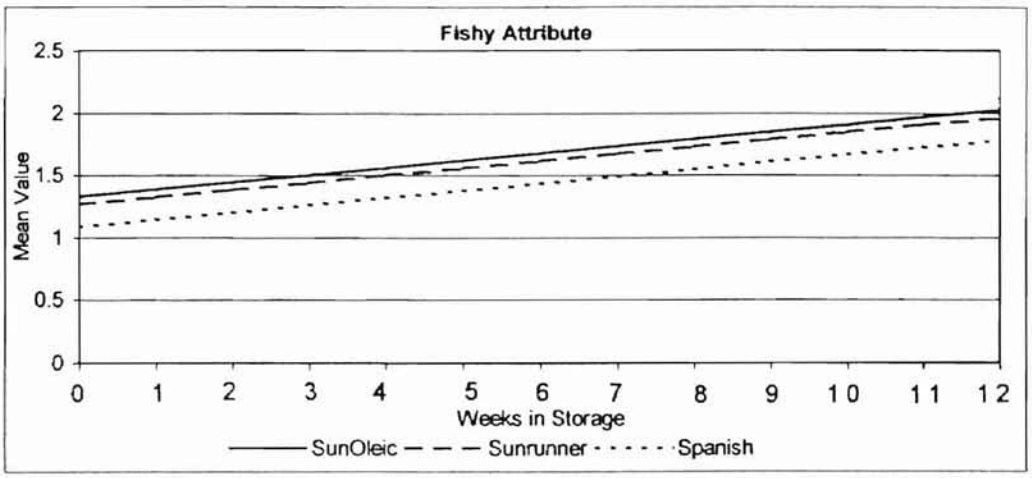
Mean Values
Weeks in Storage
SunOleic
Sunrunner
Spanish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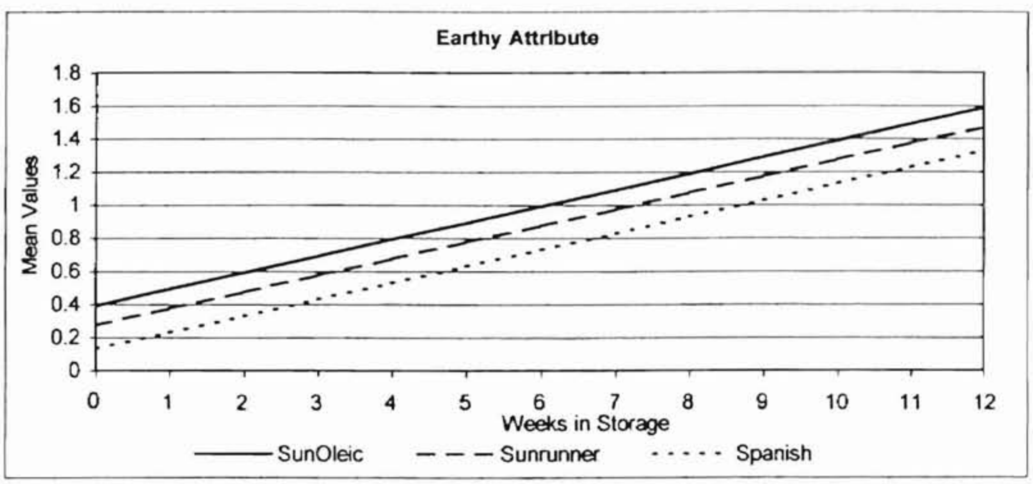
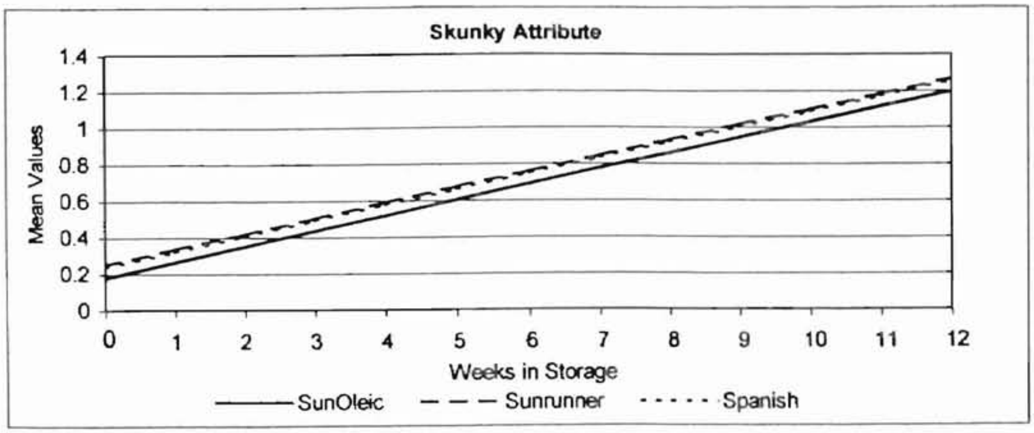
Mean Value
Weeks in Storage
SunOleic
Sunrunner
Spanish


Earthy Attribute
Mean Values
Weeks in Storage
SunOleic
Sunrunner
Spanish


Skunky Attribute
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1.2
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0.4
0.2
0
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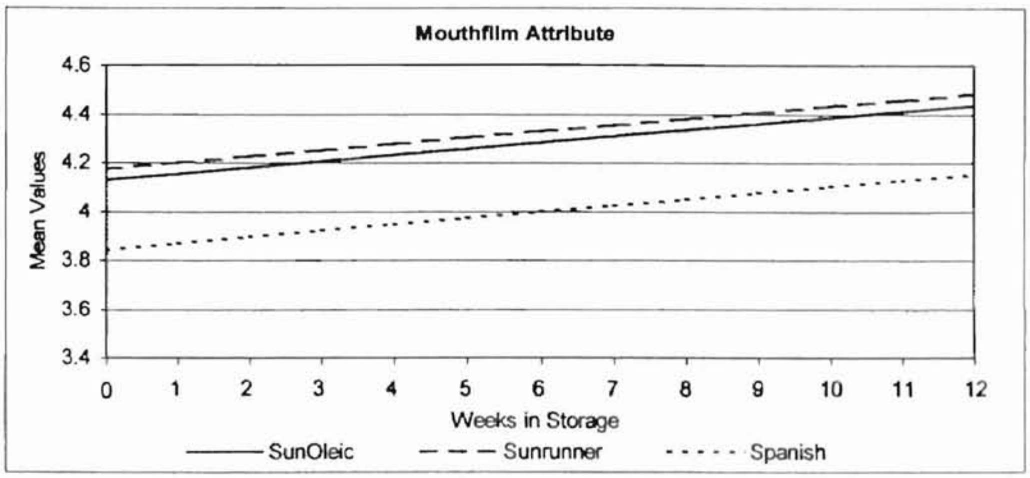
Weeks in Storage
SunOleic
Sunrunner
Spanish


Mouthfilm Attribute
Mean Values
4.6
4.4
4.2
4
3.8
3.6
3.4
0 1 2 3 4 5 6 7 8 9 10 11 12
Weeks in Storage
SunOleic
Sunrunner
Spanish

APPENDIX C

CONSUMER PREFERENCE DATA – FRESH ROAST

Judge #	bchoice	gchoice	ochoice	scoreB	scoreG	scoreO
1	1	2	3	0.85	0	-0.85
2	1	2	3	0.85	0	-0.85
3	1	2	3	0.85	0	-0.85
4	1	2	3	0.85	0	-0.85
5	1	2	3	0.85	0	-0.85
6	1	2	3	0.85	0	-0.85
7	1	2	3	0.85	0	-0.85
8	1	2	3	0.85	0	-0.85
9	1	2	3	0.85	0	-0.85
10	1	2	3	0.85	0	-0.85
11	1	2	3	0.85	0	-0.85
12	1	2	3	0.85	0	-0.85
13	1	2	3	0.85	0	-0.85
14	1	2	3	0.85	0	-0.85
15	1	2	3	0.85	0	-0.85
16	1	3	2	0.85	-0.85	0
17	1	3	2	0.85	-0.85	0
18	1	3	2	0.85	-0.85	0
19	1	3	2	0.85	-0.85	0
20	1	3	2	0.85	-0.85	0
21	1	3	2	0.85	-0.85	0
22	1	3	2	0.85	-0.85	0
23	1	3	2	0.85	-0.85	0
24	1	3	2	0.85	-0.85	0
25	1	3	2	0.85	-0.85	0
26	2	1	3	0	0.85	-0.85
27	2	1	3	0	0.85	-0.85
28	2	1	3	0	0.85	-0.85
29	2	1	3	0	0.85	-0.85
30	2	1	3	0	0.85	-0.85
31	2	1	3	0	0.85	-0.85
32	2	1	3	0	0.85	-0.85
33	2	1	3	0	0.85	-0.85
34	2	1	3	0	0.85	-0.85
35	2	1	3	0	0.85	-0.85
36	2	1	3	0	0.85	-0.85
37	2	1	3	0	0.85	-0.85
38	2	1	3	0	0.85	-0.85
39	2	1	3	0	0.85	-0.85
40	3	1	2	-0.85	0.85	0

CONSUMER PREFERENCE DATA – FRESH ROAST, cont.

Judge #	bchoice	gchoice	ochoice	scoreB	scoreG	scoreO
41	3	1	2	-0.85	0.85	0
42	3	1	2	-0.85	0.85	0
43	3	1	2	-0.85	0.85	0
44	3	1	2	-0.85	0.85	0
45	3	1	2	-0.85	0.85	0
46	3	1	2	-0.85	0.85	0
47	3	1	2	-0.85	0.85	0
48	3	1	2	-0.85	0.85	0
49	3	1	2	-0.85	0.85	0
50	3	1	2	-0.85	0.85	0
51	3	1	2	-0.85	0.85	0
52	2	3	1	0	-0.85	0.85
53	2	3	1	0	-0.85	0.85
54	2	3	1	0	-0.85	0.85
55	2	3	1	0	-0.85	0.85
56	2	3	1	0	-0.85	0.85
57	2	3	1	0	-0.85	0.85
58	2	3	1	0	-0.85	0.85
59	2	3	1	0	-0.85	0.85
60	3	2	1	-0.85	0	0.85
61	3	2	1	-0.85	0	0.85
62	3	2	1	-0.85	0	0.85
63	3	2	1	-0.85	0	0.85
64	3	2	1	-0.85	0	0.85
65	3	2	1	-0.85	0	0.85
66	3	2	1	-0.85	0	0.85
67	3	2	1	-0.85	0	0.85
68	3	2	1	-0.85	0	0.85
69	3	2	1	-0.85	0	0.85
70	3	2	1	-0.85	0	0.85
71	3	2	1	-0.85	0	0.85
72	3	2	1	-0.85	0	0.85
73	3	2	1	-0.85	0	0.85
74	3	2	1	-0.85	0	0.85
75	3	2	1	-0.85	0	0.85
76	3	2	1	-0.85	0	0.85
77	3	2	1	-0.85	0	0.85
78	3	2	1	-0.85	0	0.85
79	3	2	1	-0.85	0	0.85

CONSUMER PREFERENCE DATA – WEEK 8

Judge	bchoice	gchoice	ochoice	scoreB	scoreG	scoreO
1	1	2	3	0.85	0	-0.85
2	1	2	3	0.85	0	-0.85
3	1	2	3	0.85	0	-0.85
4	1	2	3	0.85	0	-0.85
5	1	2	3	0.85	0	-0.85
6	1	2	3	0.85	0	-0.85
7	1	3	2	0.85	-0.85	0
8	1	3	2	0.85	-0.85	0
9	2	1	3	0	0.85	-0.85
10	2	1	3	0	0.85	-0.85
11	2	1	3	0	0.85	-0.85
12	2	1	3	0	0.85	-0.85
13	3	1	2	-0.85	0.85	0
14	3	1	2	-0.85	0.85	0
15	3	1	2	-0.85	0.85	0
16	3	1	2	-0.85	0.85	0
17	2	3	1	0	-0.85	0.85
18	2	3	1	0	-0.85	0.85
19	2	3	1	0	-0.85	0.85
20	2	3	1	0	-0.85	0.85
21	2	3	1	0	-0.85	0.85
22	2	3	1	0	-0.85	0.85
23	3	2	1	-0.85	0	0.85
24	3	2	1	-0.85	0	0.85
25	3	2	1	-0.85	0	0.85
26	3	2	1	-0.85	0	0.85
27	3	2	1	-0.85	0	0.85
28	3	2	1	-0.85	0	0.85
29	3	2	1	-0.85	0	0.85

CONSUMER PREFERENCE DATA – WEEK 9

Judge	bchoice	gchoice	ochoice	scoreB	scoreG	scoreO
1	1	2	3	0.85	0	-0.85
2	1	2	3	0.85	0	-0.85
3	1	2	3	0.85	0	-0.85
4	1	2	3	0.85	0	-0.85
5	1	2	3	0.85	0	-0.85
6	1	2	3	0.85	0	-0.85
7	1	2	3	0.85	0	-0.85
8	1	2	3	0.85	0	-0.85
9	1	2	3	0.85	0	-0.85
10	1	3	2	0.85	-0.85	0
11	1	3	2	0.85	-0.85	0
12	1	3	2	0.85	-0.85	0
13	1	3	2	0.85	-0.85	0
14	1	3	2	0.85	-0.85	0
15	1	3	2	0.85	-0.85	0
16	1	3	2	0.85	-0.85	0
17	1	3	2	0.85	-0.85	0
18	2	1	3	0	0.85	-0.85
19	2	1	3	0	0.85	-0.85
20	2	1	3	0	0.85	-0.85
21	2	1	3	0	0.85	-0.85
22	2	1	3	0	0.85	-0.85
23	2	1	3	0	0.85	-0.85
24	3	1	2	-0.85	0.85	0
25	3	1	2	-0.85	0.85	0
26	3	1	2	-0.85	0.85	0
27	3	1	2	-0.85	0.85	0
28	3	1	2	-0.85	0.85	0
29	3	1	2	-0.85	0.85	0
30	2	3	1	0	-0.85	0.85
31	2	3	1	0	-0.85	0.85
32	2	3	1	0	-0.85	0.85
33	2	3	1	0	-0.85	0.85
34	2	3	1	0	-0.85	0.85
35	2	3	1	0	-0.85	0.85
36	2	3	1	0	-0.85	0.85
37	3	2	1	-0.85	0	0.85
38	3	2	1	-0.85	0	0.85
39	3	2	1	-0.85	0	0.85
40	3	2	1	-0.85	0	0.85

APPENDIX D

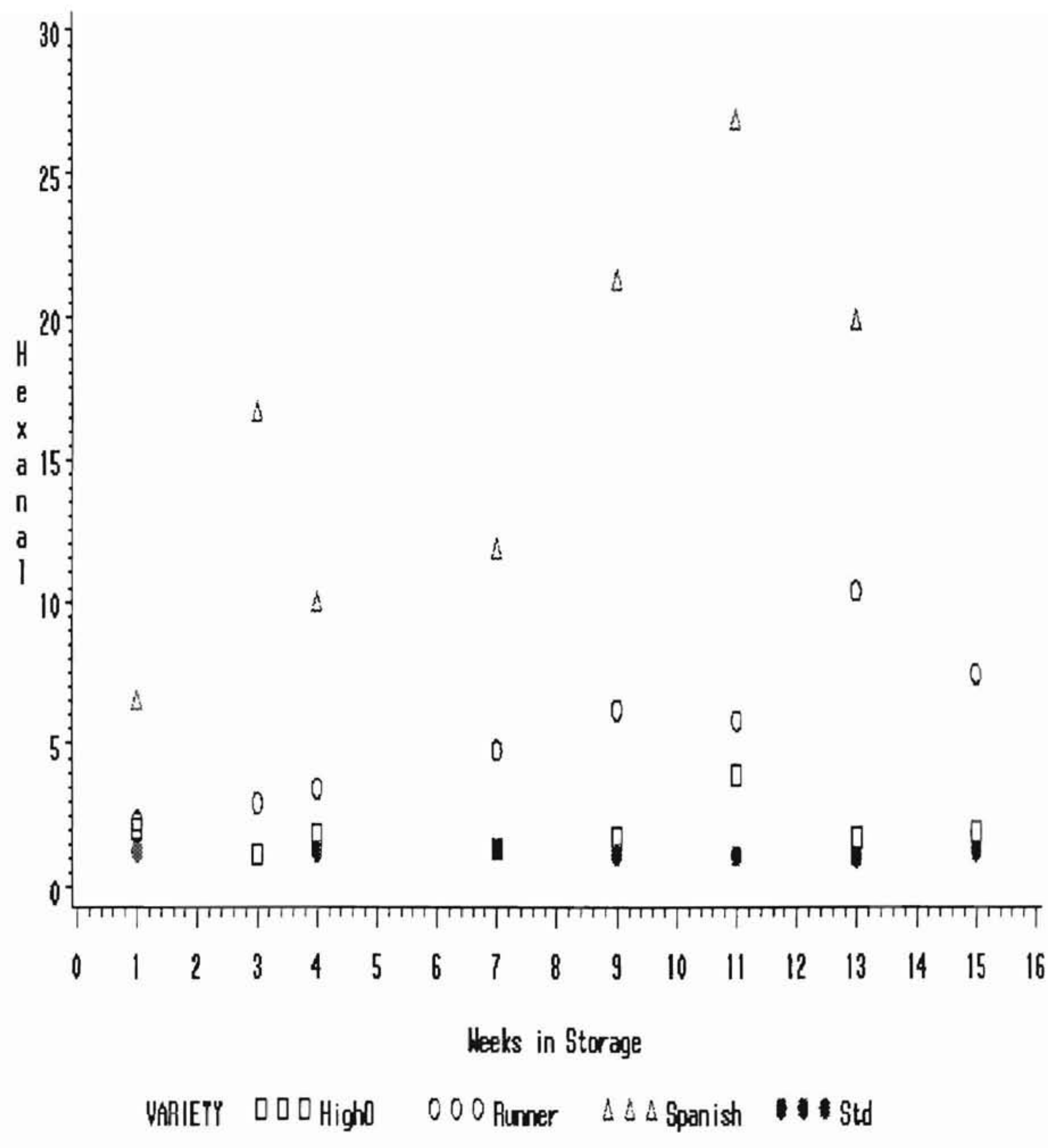


Figure 5. Hexanal means in PPM.

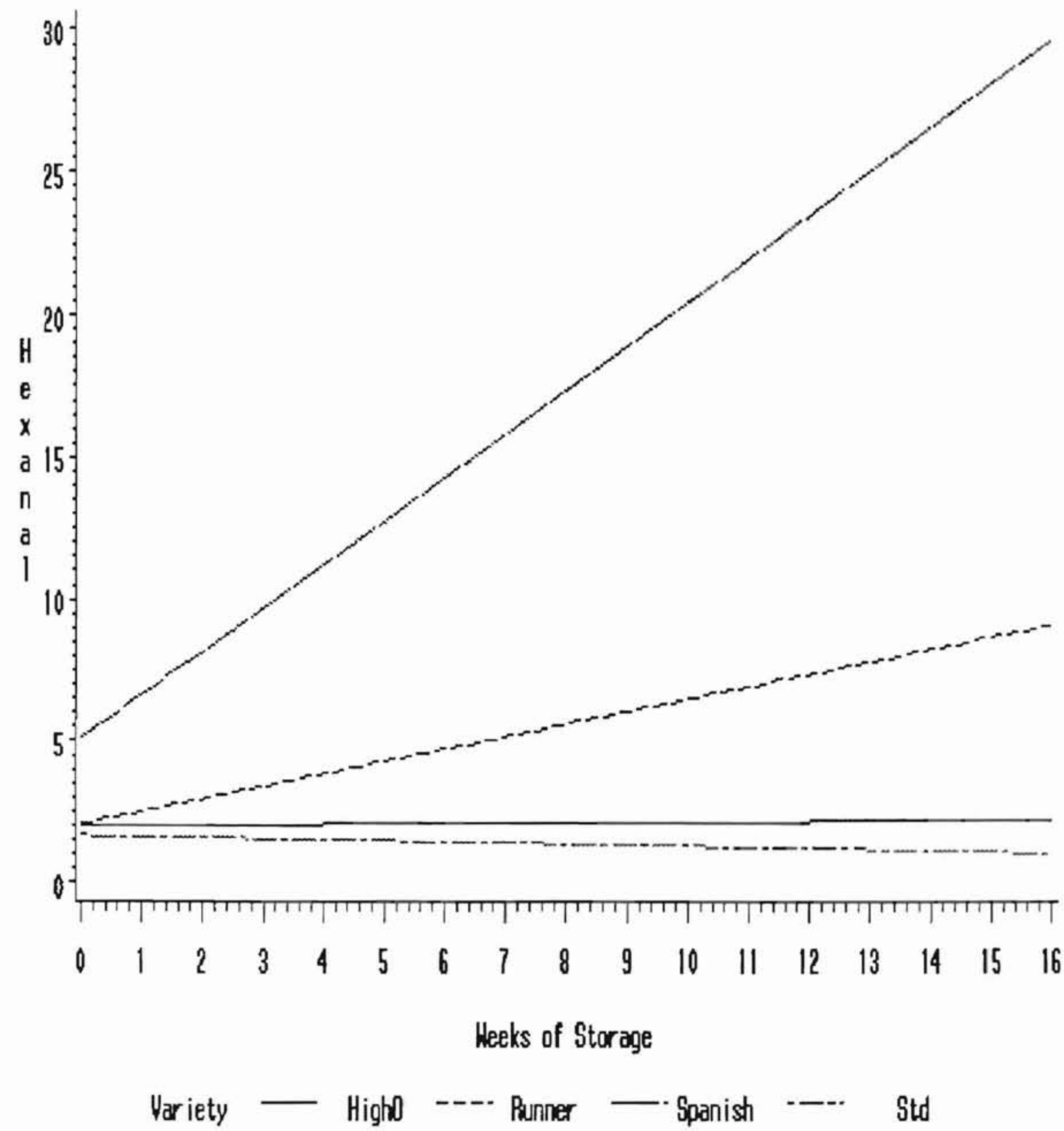


Figure 6. Slopes of Hexanal mean values (PPM) over time.

CORRELATION DATA

SUNOLEIC

Correlation Matrix

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	1.0000	0.0395	0.1379	0.4390	0.6766	0.6202	0.1634
BITTERMN	0.0395	1.0000	-0.7758	-0.0552	0.2541	0.3622	0.5044
PAINTMN	0.1379	-0.7758	1.0000	0.2485	0.2917	0.1638	-0.4646
FISHMN	0.4390	-0.0552	0.2485	1.0000	0.6866	0.7033	-0.1058
EARTHMN	0.6766	0.2541	0.2917	0.6866	1.0000	0.9514	0.1461
SKUNKMN	0.6202	0.3622	0.1638	0.7033	0.9514	1.0000	-0.0244
HEXMN	0.1634	0.5044	-0.4646	-0.1058	0.1461	-0.0244	1.0000

P-Values of the Correlations

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	0.0	0.9260	0.7447	0.2765	0.0654	0.1009	0.6991
BITTERMN	0.9260	0.0	0.0237	0.8968	0.5438	0.3780	0.2025
PAINTMN	0.7447	0.0237	0.0	0.5529	0.4833	0.6984	0.2461
FISHMN	0.2765	0.8968	0.5529	0.0	0.0600	0.0516	0.8030
EARTHMN	0.0654	0.5438	0.4833	0.0600	0.0	0.0003	0.7300
SKUNKMN	0.1009	0.3780	0.6984	0.0516	0.0003	0.0	0.9542
HEXMN	0.6991	0.2025	0.2461	0.8030	0.7300	0.9542	0.0

SUNRUNNER

Correlation Matrix

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	1.0000	0.7408	0.9114	0.8916	0.8574	0.7563	0.9808
BITTERMN	0.7408	1.0000	0.5257	0.5675	0.8231	0.8493	0.7271
PAINTMN	0.9114	0.5257	1.0000	0.9054	0.7988	0.6476	0.9093
FISHMN	0.8916	0.5675	0.9054	1.0000	0.6962	0.5956	0.8197
EARTHMN	0.8574	0.8231	0.7988	0.6962	1.0000	0.9701	0.8631
SKUNKMN	0.7563	0.8493	0.6476	0.5956	0.9701	1.0000	0.7445
HEXMN	0.9808	0.7271	0.9093	0.8197	0.8631	0.7445	1.0000

P-Values of the Correlations

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	0.0	0.0355	0.0016	0.0029	0.0065	0.0299	0.0001
BITTERMN	0.0355	0.0	0.1809	0.1423	0.0121	0.0076	0.0410
PAINTMN	0.0016	0.1809	0.0	0.0020	0.0174	0.0825	0.0017
FISHMN	0.0029	0.1423	0.0020	0.0	0.0551	0.1193	0.0127
EARTHMN	0.0065	0.0121	0.0174	0.0551	0.0	0.0001	0.0058
SKUNKMN	0.0299	0.0076	0.0825	0.1193	0.0001	0.0	0.0341
HEXMN	0.0001	0.0410	0.0017	0.0127	0.0058	0.0341	0.0

SPANCO

Correlation Matrix

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	1.0000	0.8545	0.8164	0.8280	0.9375	0.8512	0.9263
BITTERMN	0.8545	1.0000	0.9083	0.8336	0.9052	0.8177	0.7652
PAINTMN	0.8164	0.9083	1.0000	0.9509	0.8492	0.6900	0.8434
FISHMN	0.8280	0.8336	0.9509	1.0000	0.8831	0.7857	0.8312
EARTHMN	0.9375	0.9052	0.8492	0.8831	1.0000	0.9474	0.7900
SKUNKMN	0.8512	0.8177	0.6900	0.7857	0.9474	1.0000	0.6489
HEXMN	0.9263	0.7652	0.8434	0.8312	0.7900	0.6489	1.0000

P-Values of the Correlations

	WEEK	BITTERMN	PAINTMN	FISHMN	EARTHMN	SKUNKMN	HEXMN
WEEK	0.0	0.0143	0.0251	0.0214	0.0018	0.0151	0.0027
BITTERMN	0.0143	0.0	0.0046	0.0198	0.0051	0.0246	0.0450
PAINTMN	0.0251	0.0046	0.0	0.0010	0.0156	0.0862	0.0171
FISHMN	0.0214	0.0198	0.0010	0.0	0.0084	0.0362	0.0205
EARTHMN	0.0018	0.0051	0.0156	0.0084	0.0	0.0012	0.0345
SKUNKMN	0.0151	0.0246	0.0862	0.0362	0.0012	0.0	0.1148
HEXMN	0.0027	0.0450	0.0171	0.0205	0.0345	0.1148	0.0

APPENDIX E

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: **02-24-97** **IRB#:** **HE-97-048**

Proposal Title: SENSORY EVALUATION OF HIGH OLEIC ACID PEANUTS

Principal Investigator(s): Sue Knight, Faye Watson

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: John H. Wolfe Date: March 10, 1997

Chair of Institutional Review Board

cc: Faye Watson

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 04-08-97 **IRB#: HE-97-061**

Proposal Title: SENSORY EVALUATION OF HIGH OLEIC ACID PEANUTS

Principal Investigator(s): Sue Knight, Faye Watson

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: ______________ Date: April 11, 1997
Chair of Institutional Review Board

cc: Faye Watson

VITA

Faye Ann Watson

Candidate for the Degree of

Master of Science

Thesis: A COMPARISON OF ROASTED PEANUT FLAVOR ATTRIBUTES OVER TIME FOR THREE PEANUT CULTIVARS WITH DIVERS OLEIC: LINOLEIC ACID RATIOS

Major Field: Nutritional Sciences

Biographical:

Education: Graduated from Mt. Eden High School, Hayward, California in June, 1966; received Associate in Arts degree in English from Chabot College, Hayward, California in December, 1969; received Bachelor of Arts degree from Ottawa University, Ottawa, Kansas in May 1983; completed Dietetic Internship at Oklahoma State University, Stillwater, Oklahoma in January, 1997; completed requirements for the Master of Science degree with major in Nutritional Sciences at Oklahoma State University in July, 1998.

Experience: Food Service Supervisor, Woodridge Retirement Village, Stillwater, Oklahoma, July, 1994 – February, 1996. Dietetic Internship at St. Mary's Mercy Hospital, Enid, Oklahoma, June 1996 – November 1996. Research Assistant, Department of Nutritional Sciences, Oklahoma State University, Stillwater, Oklahoma, January, 1997 – June, 1998. Teaching Assistant, Department of Nutritional Sciences, Oklahoma State University, Stillwater, Oklahoma, August, 1997 – May, 1998. Research Assistant, Food and Agricultural Products Research and Technology Center, Oklahoma State University, Stillwater, Oklahoma, December, 1997 – June, 1998. Instructor, Department of Nutritional Sciences, Oklahoma State University, Stillwater, Oklahoma, November, 1997 and April, 1998.

Professional Memberships: American Dietetic Association; Oklahoma Dietetic Association; Institute of Food Technologists.

Awards: Mary B. Leidigh Scholarship, August, 1997.