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I am submitting herewith a thesis written by Linda Jayne Washam-Hutsell entitled "Evaluation of Sweet Potato Leather as a Food Product." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology and Science.

J. L. Collins, Major Professor

We have read this thesis
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Vice Chancellor
Graduate Studies and Research

EVALUATION OF SWEET POTATO LEATHER AS A FOOD PRODUCT

A Thesis

Presented for the

Master of Science

Degree

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Linda Jayne Washam-Hutsell

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ABSTRACT

The purpose of this study was to develop a sweet potato product (sweet potato leather) and to evaluate certain quality factors including chemical composition, physical and sensory attributes, and caloric content of the product.

Two types of sweet potato leather were prepared using two cultivars of sweet potato (L3-151 and Travis): recipes were designated basic sweet potato leather and basic sweet potato leather with apple. Drying rate curves were determined for the basic sweet potato leathers of both cultivars. 'Travis' basic sweet potato leather initially contained more moisture than 'L3-151' basic sweet potato leather and, consequently, after drying contained more moisture.

Proximate composition of sweet potato leathers was determined. Basic sweet potato leathers had a slightly higher moisture content than the basic sweet potato leathers with apple. In general, the addition of apple to the sweet potato leathers did not affect the composition. Caloric values also remained the same with the addition of apple.

Thickness measurements were determined for sweet potato leathers and basic sweet potato leathers prepared with apple were thinner than leathers prepared with the basic recipe. Apple contributed to the thinness of the leathers.

Hunter color measurements showed that leathers prepared with the L3-151 cultivar of sweet potato were darker, redder, and less yellow than samples prepared from 'Travis'. This was due to color differences in sweet potato cultivars. Basic recipe leather samples were lighter, redder, and more yellow than basic recipe leathers containing apple. Addition of apple produced a darker leather.

The pH of the leathers were close to each other but the leathers prepared from the basic with apple recipes had a slightly lower pH than basic recipe leathers. Tensile strength of the leathers was measured and basic recipe leathers were tougher than basic with apple leathers. No microbial counts were higher than $\log_{10}$ 2.3 for any leathers over 60 days storage period.

The leathers were evaluated by a sensory panel for flavor, texture, and overall acceptability. Included in the taste panel evaluation samples were leathers prepared from the basic recipe and dried in a kitchen oven and a solar dryer. Also included in the taste panel evaluation were leathers prepared from the basic recipe but containing 55% and 90% high fructose corn syrup instead of honey.

Leathers dried in a forced air dehydrator were rated tougher and chewier than those dried in a solar dryer and those sweetened with 55% and 90% high fructose corn syrup. 'L3-151' leathers were chewier than 'Travis' leathers. Dehydrator-dried leathers were rated stickier than those leathers dried in a solar dryer.

Basic sweet potato leathers prepared with 55% high fructose corn syrup were rated stickier than those prepared with 90% high fructose corn syrup.

This study shows that acceptable sweet potato leathers can be prepared by various drying methods and recipes. Ease of preparation and storage indicate that additional studies could be conducted to produce a marketable sweet potato product.

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CHAPTER I

INTRODUCTION

Sweet potatoes are a nutritious, high yielding root crop that can be grown in many areas of the world (27). The roots are an excellent source of vitamin A, vitamin C, B-vitamins, calcium, and energy (25, 27).

Consumption of the sweet potato has steadily declined since the early 1900's (21, 27, 42, 47). This is due to several factors; sweet potatoes are often considered to be a high caloric, fattening food; higher protein foods of animal origin are now available and more desirable; and the sweet potato is sometimes referred to as a "low status food" (27).

Since the sweet potato is an important farm crop in many countries and has such high yields, further research should be devoted to developing acceptable sweet potato products. Sweet potatoes can be prepared in many different ways, and new products should provide convenience, food quality, and ease of preparation.

The purpose of this study was to develop a new sweet potato product (sweet potato leather) and to evaluate some of the quality factors including chemical composition, physical and sensory attributes, and caloric content of the product.

CHAPTER II

LITERATURE REVIEW

I. SWEET POTATO ROOT

The sweet potato (Ipomoea batatas) originated in Central or South American lowlands about 3000 B.C. (57). The Indians of these regions grew several varieties and introduced them to early Spanish explorers who took the roots to Europe, The Phillipines, Guam, and Malaysia. From The Phillipines the sweet potato was taken to China and Japan. English explorers brought sweet potatoes to North America, and English missionaries took sweet potatoes to parts of Melanesia and Australian New Guinea. Portuguese explorers were responsible for introduction of the crop into Africa and India (27, 42, 57).

The sweet potato is a nutritious, high yielding root crop that can be grown in many areas of the world (27). Even though it is of tropical origin it can be grown over a wide range of climates (21). Sweet potatoes are an important food crop in tropical and sub-tropical regions such as South America, Africa, India, Japan, China, and parts of the United States (70).

In the United States sweet potatoes are grown commercially in the Southeastern states and portions of New Jersey, Delaware, Maryland, Illinois, Missouri, and California. Sweet potatoes have been grown successfully as far north as southern New York and Michigan (21, 25, 70).

A long, hot growing season is required for sweet potatoes. Soil temperatures of 21 to 26°C and approximately 150 frost-free days are ideal. In cooler regions plants are grown in hotbeds until soil temperatures increase enough for planting (42, 70).

Sweet potatoes can be classified into two major types based on textural properties of the cultivars. Mealy, dry-fleshed cultivars grow well in northern climates. The sweet potatoes are kept in storage for several weeks to allow some of the starch to convert to sugar. Smooth, moist-fleshed types are a deeper orange in color and have a sweeter flavor than the dry-fleshed type when cooked (25, 27, 42, 62).

Sweet potatoes have an attractive appearance, desirable taste, a high provitamin A content, and are a source of food for millions of people in tropical regions of the world (21, 57). Consumption of sweet potatoes could be increased with development of desirable sweet potato products.

II. NUTRITIONAL VALUE OF SWEET POTATOES

Sweet potatoes contribute many important vitamins and minerals to the diet (21) and have a high nutrient content relative to calories (47). On a dry-weight basis the sweet potato is composed of 89.5% total carbohydrate, 5.8% protein, 1.4% fat, 3.4% ash, and 2.4% fiber (73). An average sweet potato provides 880 retinol equivalents of vitamin A per 100g, 22 mg of vitamin C per 100g, appreciable amounts of the B vitamins (thiamine, riboflavin,

niacin), and significant amounts of certain minerals (25, 42, 73). A 100 gm serving of sweet potato contains approximately 114 kcal (18, 19).

Although the sweet potato is highly nutritious and has high production potential, consumption has declined steadily over the years (21, 27, 42, 47). In 1919, per capita consumption was 13.29 kg and in 1974 consumption had decreased to 2.54 kg (18, 19, 20, 25).

Sweet potatoes have declined in popularity for several reasons. Sweet potatoes are often considered to be a high caloric, fattening food and are avoided by weight conscious people. Many snack foods and instant foods are available and may have replaced sweet potatoes in the diet. Higher protein foods of animal origin are available and consumed in greater amounts than foods of plant origin. Sweet potatoes are associated with holiday meals in some areas of the country and may be consumed only at certain times of the year (27). To increase sweet potato consumption people must be convinced of its nutritional value, and new acceptable sweet potato products must be developed (27, 47).

III. SWEET POTATO PRODUCTS

To increase the consumption and acceptance of sweet potatoes, new products have been developed over the past several years.

New processed foods which offer convenience and ease of preparation are necessary (18). Acceptable deep fried sweet potato products such as sweet potato chips, julienne strips, dices, and french fries have been prepared experimentally (36, 44).

An experimental frozen sweet potato product was prepared from baked cured roots. Various flavorings such as raisins, pineapple, and coconut were added to the baked sweet potato before freezing. The product only needed heating before serving. Panel scores indicated the product was very acceptable (18, 19, 20).

Dehydrated sweet potatoes were used as a food staple during World War II (25). Dehydrated sweet potato flakes can be reconstituted in a short time and are reported to have the color and taste of fresh pureed sweet potatoes (35).

Sweet potatoes have been canned for many years. Canned potatoes are not very popular due to the lack of sweet potato flavor, a dry kinesthetic sensation, and a color loss (18, 34).

IV. HIGH FRUCTOSE CORN SYRUP

High fructose corn syrups (HFCS) were introduced in 1967 and have become increasingly popular as a sugar substitute. Production has doubled every two years and estimates predict that HFCS may eventually control up to 50% of the industrial sweetener market or approximately 35% of the total caloric sweetener market (71). HFCS is used as a sucrose substitute in foods such as bakery

products, confections, processed foods, dairy products, and beverages (37, 48, 71).

High fructose corn syrup is a clear liquid, low-viscosity sweetener high in the simple sugar fructose. It can be used as a substitute sweetener in all products that do not require a crystalline structure. HFCS works excellently in fruit flavored products since it enhances the flavor and adds sheen and color to the product (71).

High fructose corn syrup is manufactured in fructose concentrations of 42 to 90%. First generation high fructose corn syrups (42% fructose, 50% dextrose, 8% higher saccharides) are used mainly as partial, not total, replacements for sucrose. Second generation high fructose corn syrups can be used to replace sucrose and contain 55 to 90% fructose (37, 43, 48, 71).

The 55% HFCS is used as a replacement for sucrose and has been used in cereals, jams, jellies, salad dressings, and soft drinks. Eventually, 55% HFCS may replace 50 to 100% of the sucrose used in soft drinks (43, 48).

Ninety percent HFCS can be used as a natural sweetener in reduced and low calorie foods. It contributes the same amount of calories/gram as sucrose, but it is 110-160% greater in perceived sweetness (22, 48). Therefore, reduced quantities can be used to achieve the same level of perceived sweetness in foods which yield a low or reduced calorie product (13, 58, 71).

Use of HFCS as a sugar substitute will depend largely on sugar prices. Consumption of HFCS should increase with consumer familiarity with the product and the trend toward lower calorie and sugar intake (43, 71).

V. DEHYDRATION-HISTORICAL BACKGROUND

Preservation of food by drying has been practiced for centuries (16, 24, 26, 52, 55). Long before Biblical times Chinese, Hindus, Persians, Greeks, and Egyptians dried herbs, fruits, and vegetables utilizing the sun and wind (63). Two thousand years ago the Inca Indians dried white potatoes by a natural freeze drying process. The dried product, known as "chuno" was made by freezing potatoes, thawing them, and walking on the thawed potatoes to squeeze out the excess juice. Peruvian Indians made a product from sun-dried white potatoes called "tunta." Early American settlers prepared a product called "samp" by sun-drying sweet corn cut from the cob (55, 63). Utilizing the sun and wind for drying is still popular in many areas of the world.

Although sun-drying dates back thousands of years, dehydration (artificial drying) is limited mostly to the nineteenth and twentieth centuries (63). Dehydrated vegetables were used by the Union Army during the Civil War to prevent starvation and scurvy. However, the vegetables were so distasteful that many soldiers would not eat them. The procedures at that time for pretreating, drying, and packaging the vegetables were not developed

and did not prevent off flavors and color and vitamin losses (29, 52).

Acceleration of dehydration technology came during World War I. Many dehydrated foods such as fruits, vegetables, and soups were shipped to American soldiers in Europe. Most of the fruits and vegetables were not blanched before dehydrating and were dried in poorly operated and controlled dehydrators. Products had very little flavor and were tough in texture (29, 55, 63).

Between World War I and World War II little progress was made in dehydration technology. Consumer acceptance was too low for mass production of dehydrated products to become feasible (29, 54).

World War II revived production, research, and development of dehydrated food products. Transportation costs and food spoilage were greatly reduced by shipping commodities such as dehydrated meats, vegetables, and soups to the Allied Military Forces. Many dehydration companies were in operation by the end of the war (29, 32, 50, 54, 63).

Transition from a wartime necessity to a commercial industry was slow and not much progress was made until the 1950's. Potato granules, potato flakes, dehydrated meats, and soups became common in supermarkets (29). These products sold well because of their shelf life stability and ease of preparation.

VI. NUTRITIONAL VALUE OF DEHYDRATED FOODS

Drying removes most of the moisture from foods and subsequently increases the concentration of nutrients present in the product. Proteins, fats, and carbohydrates are present in greater amounts per unit weight than in fresh foods (24). The content of some vitamins decreases in dehydrated foods. Fat soluble vitamins are partially oxidized and water soluble vitamins are partially lost during blanching and enzyme inactivation. The extent of vitamin destruction can be controlled somewhat during processing. The dehydration process selected, the care of the food during preparation, and storage conditions of dried food all determine the extent of vitamin destruction (12, 24, 32, 45, 46).

Vitamin retention in dehydrated foods is generally greater than sun-dried foods. Large amounts of the carotenes and vitamin C are lost during slow sun drying processes. A greater percentage of ascorbic acid is retained when rapid drying processes are utilized (51).

The β-carotene content of dehydrated vegetables is usually 70-100% of that found in fresh vegetables when the product is dried properly. Niacin, riboflavin, and pantothenic acid losses are marginal, but thiamine is heat sensitive and easily destroyed (12).

Rancidity is a problem in dried foods. Oxidation of lipids in foods is greater at high temperatures and with a high degree of

unsaturation. Rancidity can be minimized by reducing available oxygen, by storing at low temperatures, by adding antioxidants, by controlling moisture content, and by packaging in opaque containers (66).

Dehydrated food products are equally as nutritious as other processed foods. Some vitamin content is lost, but this can be minimized by pretreatments and the addition of antioxidants (63).

VII. MICROBIOLOGY OF DRIED FOOD PRODUCTS

One of the main reasons for preserving food by drying is to reduce the amount of free water so that growth of microorganisms is greatly reduced (14, 38, 41, 53). Dehydration of the microbial cell and its environment causes metabolic activities to cease and the total viable population is decreased (60). Factors other than water content affect the type and number of microorganisms present in dehydrated food products. The type of food, microbes present in unprocessed food, treatment of food before dehydration, and the physical conditions to which the dried organisms are exposed all determine the final microbial count (53, 60, 64, 65).

Microbial spoilage is not a common occurrence in dehydrated food products, and very seldom have any pathogenic organisms been isolated (53). However, microbes present in dried foods can affect the quality of food (72).

Heat resistant spore-forming bacteria are the most common contaminants of dried products. Many bacteria of the Bacillaceae family are harmless, but dried products can contain pathogenic

species such as Bacillus cereus and Clostridium perfringens. Enterobacteriaceae can survive for a long time in dried foods. Members of this family such as Salmonella have been found in dried foods even after being fully processed by heat during manufacture. Staphylococcus aureus has been detected in some dehydrated products. During the gradual decrease in water activity, S. aureus grows in the absence of competition. Bacterial cells are killed eventually by the drying process, but preformed heat stable toxins remain unaffected (53).

Molds may grow on dried products when the water activity is marginal to mold growth (A_w = 0.60). Also mycotoxins may be formed during mold growth on raw materials before drying (53).

To prevent bacterial contamination of dehydrated products preventative measures should be taken. The microbiological quality of raw materials and equipment should be examined.

The air supply used for dehydrating should be clean and dehydrator trays should not be overloaded. Packaging materials should be tested, microbiologically, and the finished product should be checked for physical damage which could lead to microbiological contamination (53, 65, 72).

VIII. FRUIT LEATHERS

Fruit leathers are prepared from the puree of various fruits and vegetables (17, 30). Fruits and vegetables such as apples, bananas, pears, peaches, berries, grapes, apricots, plumbs, tomatoes,

carrots, and sweet potatoes can be used to prepare fruit and vegetable leather (56, 61, 74). Ripe fruit or imperfect fruits that are not suitable for canning can be used in fruit leathers (17). Some purees must be heated to inactivate enzymes that can cause a change in color and flavor (6, 63). The puree can be lightly sweetened and spiced if desired (30, 74).

Puree is spread in thin layers on plastic wrap or freezer wrap and placed in a dehydrator, electric oven or in the sun to dry. Dehydrator dried leathers will dry in 8 to 12 hours, electric oven leathers require 4 to 8 hours at 60°C, and solar dried leathers will dry in one to two days (49). The thicker the layer of puree the longer the time required for drying.

Leather is ready for removal from the drier when it feels dry to the touch, but still soft enough to roll (6, 30). If the leather feels very sticky it may be too moist for removal from the dehydrator.

For storage, leather can be rolled up in plastic wrap or waxed paper, and then overwrapped in plastic or aluminum foil. Fruit leathers should be stored in a cool, dark, dry place. Leathers should be kept in a freezer for extended storage (17, 49, 61, 63).

Fruit leather makes a tasty and nutritious snack food for home, hiking, school, or work. It can also be used as a fruit flavoring for baking and making sauces (5, 15, 61).

IX. ADVANTAGES OF DEHYDRATION

Dehydrated food products offer many advantages to both the processor and the consumer (23, 68). These include:

1. Dehydrated fruits and vegetables provide sources of energy, minerals, and vitamins (10, 24, 63).

2. Preservation of harvested produce by dehydration minimizes post-harvest spoilage and helps offset shortages in supplies (63).

3. Preservation method is less costly. Preparation of the product is fast and easy, a minimum of labor is required, processing equipment needed is limited, and transportation costs are cut tremendously (24, 33, 68, 69).

4. Dried foods have less weight and volume than fresh, frozen, or canned foods (33, 40, 52, 68).

5. Many dehydrated foods are suitable for consumption with no additional preparation (10, 33, 69).

6. There is a reduced risk of microbial spoilage due to the low moisture content of dehydrated foods (24).

7. When cooked, dehydrated fruit products closely resemble cooked fresh fruit in taste and color (23).

The advantages of dehydration should make this method of drying foods increasingly popular. It may be the main method for providing food for the world's undernourished and malnourished peoples in the future (68).

X. DEHYDRATED FOOD PRODUCTS

Dehydrated food products are numerous and are used throughout the world where fresh foods are not available year round. Dried foods are purchased in great quantities by military operations.

The products are lightweight, economical, and space saving (63). As the demand for dehydrated foods increases, so does the number of new products on the market. Many fabricated products are prepared from ingredients of dehydrated fruits and vegetables. If necessary, these products can be enriched and fortified (50, 63).

Instant fruit drinks are prepared from dehydrated fruit flakes. The fruit flakes are sweetened with sugar, fortified, and antioxidants are added. The product is mixed with water by the consumer (24).

Fruit disks are added to breakfast cereals. These are prepared by compressing fruit flakes into disks by a pellet press. The bite size pieces have a good fruit flavor, appearance, and storage stability (63).

Puffed apple chips are a crispy snack food with a fresh fruit flavor. Moisture content of the apple chips is 2% or less (63).

Soy-banana powder can be made from a slurry of soybeans and bananas. The slurry is dehydrated to a moisture level of 3%. The product has a pleasant flavor, is easily reconstituted, has a good shelf life, and can be used as a weaning food for babies. Other fruits and legumes could be substituted for the bananas and soybeans (63).

Most all fruits, vegetables (except leafy vegetables and melons), spices, meats, and fishes can be dehydrated to yield an acceptable and nutritious product.

XI. FACTORS AFFECTING STORAGE STABILITY OF DEHYDRATED FOODS

Dehydrated food products have the potential to last years provided they are protected from the deleterious effects of their surroundings. The shelf life of a dehydrated food depends on a number of factors. It is necessary to know the extent of protection required to maintain a high quality product (9).

Moisture content of a dehydrated product must be closely controlled. Water rehydrates the product and makes it susceptible to the same spoilage as fresh and canned foods (11). Any increase in moisture content will increase the rate of chemical and enzymatic action, shortening the shelf life of the product. As moisture levels increase microorganisms are more likely to grow (56).

Storage temperatures should be relatively low to maximize storage life of dehydrated products. During storage, products give off carbon dioxide and absorb oxygen. For every increase in temperature of 10°C the transfer of these gases may quadruple (63). Enzyme systems may become operative at elevated temperatures (11). High storage temperatures accelerate microbial growth and the degradation of many nutrients such as ascorbic acid, thiamine, and amino acids (63).

Light is detrimental to dehydrated fruits and vegetables. It can cause degradation of light-sensitive vitamins including riboflavin, carotene, thiamine, and amino acids (63).

Sulfur dioxide may be used to extend the shelf life of dehydrated fruits and vegetables subject to governmental approval. The fruits and vegetables maintain their light, natural color during extended storage (63).

Many of the storage losses in dehydrated products can be reduced by the correct selection of packaging materials and methods. Correct packaging of food can control losses from the effects of moisture, temperature, light, and microorganisms (56).

Packaging varies with the type of product and the storage conditions. Rigid or flexible packaging can be used. Rigid containers consist of metal cans and glass jars. They protect against gas or vapor transfer and give the product physical protection. A nitrogen headspace can be added to extend the life of the product. Impervious containers protect products but are space consuming and expensive (9, 56, 63).

Two types of flexible packaging are available for dehydrated products. Products with a long shelf life require complete protection from oxygen, light, and moisture. Aluminum foil provides an excellent barrier and is usually a component of the package (11). Dehydrated food products with a short shelf life or those which do not require protection from light or oxygen can be packaged in transparent, translucent, or pigmented plastic materials (9).

Flexible packages do not offer as much product protection as rigid containers. However, they are less expensive than rigid containers and maximize available storage space.

CHAPTER III

MATERIALS AND METHODS

I. SOURCE AND TYPE OF SWEET POTATO

The Travis cultivar and the L3-151 breeding line of sweet potatoes were used in the experiment. Travis is a new cultivar and formerly had been the breeding line L4-62 (31).

The sweet potatoes were grown on the Plant Science Farm, The University of Tennessee, Knoxville, by personnel of the Plant and Soil Science Department. Roots were harvested and cured by recommended methods.

II. PREPARATION OF SWEET POTATO ROOTS

Cured roots were washed with water, wiped dry, and baked until soft for 2 to 2.5 hours at 191°C in a "Despatch" oven. The baked roots were allowed to cool to room temperature, peeled by hand, and pureed with a Hobart Food Processor (Model 84142). Pureed potatoes were packaged into one pound bags and frozen and held at -17°C until used.

III. PREPARATION OF SWEET POTATO LEATHER

Bags of the frozen sweet potato puree were thawed and leather was prepared by adding the amounts of ingredients presented in Table 1. Fruit leathers were prepared using Standard American measurements.

TABLE 1. Ingredients Utilized to Make Sweet Potato Leather

Ingredients	Measurements	
	Standard American	Metric
Evaporated milk	1/2 cup	116 gms
Honey	1/4 cup	79 gms
Salt	1/8 tsp.	0.9 gm
Margarine	1 tbsp.	13 gms
Crushed pineapple	1/3 cup	71 gms
Cinnamon	1/4 tsp.	0.6 gm
Allspice	1/8 tsp.	0.1 gm
90% HFCS[1]	1/4 cup	77 gms
55% HFCS[2]	1/4 cup	76 gms
L3-151 sweet potato for basic recipe	1-1/2 cups	384 gms
L3-151 sweet potato for basic with apple recipe	3/4 cup	205 gms
Travis sweet potato for basic recipe	1-1/2 cups	338 gms
Travis sweet potato for basic with apple recipe	3/4 cup	192 gms
Winesap apples	3/4 cup	184 gms

[1]Ninety percent high fructose corn syrup.

[2]Fifty-five percent high fructose corn syrup.

The ingredients used in each recipe are presented in Table 2. Comparison of Table 1 and Table 2 indicate ingredients and the amount of each ingredient in each sweet potato leather used in this study.

Sweet potatoes, salt, honey, evaporated milk, and margarine were combined and blended in a mixing bowl. Crushed pineapple was blended at high speed in a blender for seven minutes to obtain smooth consistency. Pineapple, cinnamon, and allspice were mixed together and added to the sweet potato mixture.

One hundred twenty-five grams of sample were weighed onto "Tite Brand Freezer Wrap." The wrap was coated thinly with margarine to prevent the leather from sticking to the paper. A glass rod was used to spread sweet potato leather paste into thin sheets between two metal spacers. The metal spacers were used to obtain uniform layers of paste.

Sheets of leather were put into a forced air dehydrator at 49°C until dry. Sweet potato leather was removed from the dehydrator and wrapped in waxed paper overlaid with aluminum foil for storage.

The recipe presented above was used to prepare 'Travis' and 'L3-151' basic sweet potato leather. Basic sweet potato leather with apple was prepared also from L3-151 and Travis cultivars. The recipe was similar to the basic recipe with one exception. Instead of adding one and one-half cups of sweet potato, three-fourths cup of sweet potato and three-fourths cup of apple were added. Apples of Winesap cultivar were used. Three replications were prepared.

TABLE 2. Sweet Potato Leather Ingredients and Recipes

Recipes	L3-151	Travis	Winesap Apples	90% HFCS	55% HFCS	Evaporated Milk	Honey	Pineapple, Margarine Salt, Cinnamon, Allspice
L3-151 Basic	+[1]	-[2]	-	-	-	+	+	+
Travis Basic	-	+	-	-	-	+	+	+
L3-151 Apple	+	-	+	-	-	+	+	+
Travis Apple	-	+	+	-	-	+	+	+
L3-151 90% HFCS	+	-	-	+	-	+	-	+
L3-151 55% HFCS	+	-	-	-	+	+	-	+

[1] + = ingredient included in recipe.

[2] - = ingredient not included in recipe.

'L3-151' basic recipe sweet potato leather was prepared using high fructose corn syrup as a sweetener instead of honey. Ninety percent high fructose corn syrup and 55% high fructose corn syrup (Cornsweet High Fructose Corn Syrup, ADM Corn Sweeteners) were used to prepare the leather. Samples were placed in a forced-air dehydrator to dry. The dried leather was wrapped in waxed paper overlaid with aluminum foil for storage. Three replications of each level of high fructose corn syrup were dried.

IV. DRYING METHODS

Sweet potato leather prepared by the 'L3-151' basic recipe was dried by three methods. Samples were dried in a forced-air dehydrator, a solar dryer, and a kitchen oven. Each drying method was replicated three times. Each sheet of leather contained 125 gms of sample. The sample was spread evenly between two metal spacers with a glass rod to obtain the same thickness for each sheet of leather. Dried sweet potato leather was wrapped in waxed paper overlaid with aluminum foil for storage.

V. DRYING RATE OF SWEET POTATO LEATHER

Samples, consisting of 'L3-151' and 'Travis' basic recipes, were dried in a forced air dehydrator to determine the drying rate. Relative humidity of the room was determined using a Taylor wet-dry bulb hydrometer. Loss of moisture during the drying cycle was measured by weighing the samples at one hour intervals until

negligible moisture loss occurred. Thereafter the leathers were weighed at one-half hour intervals until three readings of the same weight were obtained and drying was terminated.

VI. CHEMICAL ANALYSES OF SWEET POTATO LEATHER

Determination of Proximate Analyses

Moisture. Moisture content of sweet potato leather was determined by the AOAC Vacuum Oven Method (7). Triplicate samples of two grams were dried to a constant weight at 70°C and 55.88 cm Hg under vacuum. Percentage of moisture was calculated.

Crude Fat. Five grams of oven-dried sample were extracted for 16 hours with petroleum ether in a Goldfisch Apparatus according to AOAC (7). Percentage of total lipid content was calculated on dry weight basis.

Crude Protein. Total nitrogen was determined by the modified Kjeldahl method (7). Two grams of oven-dried sample were analyzed in triplicate for total nitrogen content. Percentage of crude protein was calculated on dry weight basis by multiplying percentage of nitrogen x 6.25.

Ash. The percentage of ash was determined according to AOAC (7). Two grams of each sample were ashed in a Muffle Furnace at 525°C until the sample reached constant weight. Percentage of ash was calculated on dry weight basis.

Crude Fiber. Crude fiber content of sweet potato leather was determined by digesting the samples with 1.25% solution of sulfuric acid and then with 1.25% solution of sodium hydroxide. The dried residue remaining after digestion was weighed and then incinerated in a muffle furnace at 550°C for 20 minutes (7). Percentage of fiber was calculated on dry weight basis.

Nitrogen Free Extract. Nitrogen free extract was determined by subtracting the percentage of crude fat, crude protein, ash, and crude fiber from 100%.

Neutral Detergent Fiber (NDF) Determination. Samples were analyzed for amount of cell wall constituents by the modified NDF procedure (28). One gram of oven-dried sample was placed into a 600 ml refluxing beaker. One hundred milliliters of cold (20°C) neutral detergent solution (28), 2 mls decahydronaphthalene, and 0.5 grams sodium sulfite were added to the beaker and the mixture was refluxed for 60 minutes. The solution was filtered in a tared sintered glass crucible set on a filter manifold. The filtered mat was broken up with a glass rod and washed twice with 100°C water. Washing was repeated with acetone until the filtrate was colorless. The NDF was dried overnight at 100°C, cooled in a desiccator, and weighed. The yield of NDF was expressed as percentage of cell-wall constituents. An estimate of soluble cell material was made by subtracting this value from 100%. By ashing the residue in the crucible for three hours at 550°C, ash insoluble content in the neutral detergent (NDF fraction) was determined.

VII. ENERGY DETERMINATION

Caloric value was determined with an Oxygen Bomb Calorimeter (3). An 0.8 gram oven-dried sample was analyzed in triplicate. Energy values were determined by complete oxidation of the sample. Caloric value was determined by measuring the rise in temperature of a specific volume of water.

VIII. COLOR MEASUREMENT OF SWEET POTATO LEATHER

Color determinations were made on sheets of sweet potato leather from each treatment using the Hunter Color/Difference Meter (Model D25D2M). L, "a" and "b" values were recorded for the surface of the leather. The instrument was standardized against an orange ceramic reference tile (L=58.5, "a" = +29.4, "b" = +33.1). Three replications were prepared and observations were measured at 0, 30, and 60 days.

Tensile Strength of Sweet Potato Leather

The Instron Food Testing Machine (Model 1132) was used to measure the tensile strength of sweet potato leather (4). A template was constructed according to American Society for Testing and Materials (ASTM) dimensions (1). Leather was cut in the shape of the template and placed between clamps on the Instron. The 500 gram capacity load cell was used; the crosshead and chart speeds were set at 2.5 cm per minute. Four measurements were made on each of three replications of samples. Samples were tested at 0, 30, and 60 days.

IX. pH OF SWEET POTATO LEATHER

Ten grams of leather were mixed with 50 ml of reboiled distilled water. The leather was homogenized in a Virtis "45" homogenizer at a setting of 100 for three minutes.

A Corning pH Meter (Model 7) was standardized using buffers with a pH of four and a pH of seven. The meter was allowed to equilibrate for 20 minutes before reading. Samples were read at 0, 30, and 60 days and three replications of each sample were prepared.

X. MICROBIOLOGICAL EXAMINATION OF SWEET POTATO LEATHER

Microbiological tests were conducted on sweet potato paste (sweet potato leather mixture before dehydration) and on sweet potato leather. Sweet potato paste was tested at preparation. Sweet potato leather was tested at 0, 30, and 60 days. Dilution blanks (10^1 to 10^4) were plated for bacterial, yeast, and mold counts. Standard Methods Agar was used for standard plate counts. Petri plates were incubated at 32°C for 48 hours. Coliform counts were determined using Violet Red Bile Agar incubated at 37°C for 24 hours. Yeast and mold counts were determined using Acidified Potato Dextrose Agar incubated at 21°C for seven days (2). Baird Parker Agar was used to determine Staphylococcus counts. Plates were incubated at 37°C for 48 hours.

XI. SENSORY EVALUATION OF SWEET POTATO LEATHER

A consumer profile technique was used to evaluate sweet potato leather for each treatment (67). Basic recipe sweet potato leather and basic sweet potato leather with apple prepared with 'L3-151' and 'Travis' were evaluated after 60 days storage. Solar-dried and oven-dried samples prepared from 'L3-151' basic sweet potato leather recipe were evaluated after 60 days storage. Basic recipe sweet potato leather prepared with 55% and 90% high fuctose corn syrup was evaluated by the panelists after 60 days storage. A semantic differential scale was used to evaluate texture, flavor, and overall acceptability (39, 59, 67). A six-point scale was used with descriptive words applicable to sweet potato leather. A value of one indicated the complete absence of a given characteristic and a value of six indicated the presence of the characteristic to a high degree. Each panelist received four combinations from the eight samples.

XII. STATISTICAL ANALYSIS

Proximate analysis, gross energy, neutral detergent fiber, and micrometer data of sweet potato leather were analyzed by analysis of variance as a factorial of a completely randomized block (2x2x3; cultivar of sweet potato x recipe x replication).

Data for color, pH, and texture were analyzed by analysis of variance as a factorial of a completely randomized block (2x2x3x3; cultivar of sweet potato x recipe x replication x days of storage).

Data for microbiological examination were presented as log counts. Data collected from drying rates of 'Travis' and 'L3-151' was reported in graphical form as loss of moisture with time of drying. Sensory evaluation data was analyzed by analysis of variance as a factorial of a balanced incomplete block design with panelists receiving four combinations of sample.

Duncan's Multiple Range Test was used to determine significance among the means where appropriate (75). All data were analyzed using the Statistical Analysis System (SAS) of The University of Tennessee Computer Center (8).

CHAPTER IV

RESULTS AND DISCUSSION

I. PROXIMATE COMPOSITION OF SWEET POTATO LEATHER

Table 3 presents the F-ratios for each component of the proximate analysis. The amounts of crude protein and ash were affected at the 0.01 level by cultivar and recipe. Moisture content was affected by the recipe at the 0.05 level. Amounts of crude protein and ash were affected (0.05 level) by the interaction between cultivar and recipe. The moisture content among replications was different at the 0.05 level.

The means for proximate analysis of the sweet potato leather as affected by cultivar and recipe are presented in Table 4. Travis cultivar sweet potato leathers contained a higher (0.01 level) amount of protein than leathers prepared with L3-151 cultivar sweet potato. L3-151 cultivar leathers contained a higher (0.01 level) amount of ash than leathers prepared from Travis cultivar. Leather prepared from the basic recipe had a higher (0.05 level) amount of moisture than basic recipe prepared with apples. Leathers prepared from the basic recipe had the higher amount of ash (0.01 level). Leathers prepared by the incorporation of apple to the basic recipe had the higher (0.01 level) amount of protein. No differences were evident between recipes for the remaining components.

TABLE 3. F-Ratios and Error Mean Squares for Proximate Analysis of Sweet Potato Leather

Source	D.F	Moisture	Crude Protein	Crude Fat	Ash	Crude Fiber	Carbohydrate
Total	11	--	--	--	--	--	--
A. Cultivar	1	0.43^{NS}	32.48**	0.67^{NS}	75.71**	5.12^{NS}	1.00^{NS}
B. Recipe	1	6.78*	16.47**	3.45^{NS}	27.26**	0.00^{NS}	0.02^{NS}
A x B	1	5.15^{NS}	9.30*	0.01^{NS}	8.24*	0.83^{NS}	2.29^{NS}
Replication	2	10.59*	0.62^{NS}	0.73^{NS}	1.55^{NS}	2.54^{NS}	1.72^{NS}
		Mean Squares					
Residual Error	6	0.118	0.019	0.112	0.004	0.019	0.316

*Significant at 0.05 level.

**Significant at 0.01 level.

^{NS}Not significant at the 0.05 level.

TABLE 4. Means[1] for Proximate Analysis of Sweet Potato Leathers as Affected by Cultivar and Recipe

	Moisture,%[3]	Protein, %[3]	Crude Fat, %[3]	Ash,%[3]	Crude Fiber,%[3]	Carbohydrate,%[3]
Cultivar						
L3-151	6.0[a]	5.6[a]	4.8[a]	2.9[a]	2.1[a]	84.7[a]
Travis	5.8[a]	6.0[b]	5.0[a]	2.4[b]	2.3[a]	84.1[a]
Recipe[2]						
Basic	6.2[x]	5.6[x]	4.7[x]	2.8[x]	2.2[x]	84.7[x]
Basic with Apple	5.7[y]	5.9[y]	5.1[x]	2.5[y]	2.2[x]	84.2[x]

[1]Means of six measurements.

[2]See Table 2 for recipes.

[3]Calculated on a dry weight basis.

[a-b]Means of proximate composition for protein and ash followed by different letters are different at the 0.01 level. Means of proximate composition for moisture crude fat, crude fiber, and carbohydrate followed by the same letter are not different at the 0.05 level.

[x-y]Means of proximate composition for moisture followed by different letters are different at the 0.05 level. Means of proximate composition for protein and ash followed by different letters are different at the 0.01 level. Means of proximate composition for crude fat, crude fiber, and carbohydrate followed by the same letter are not different at the 0.05 level.

The proximate composition of sweet potato leather as affected by the cultivar x recipe interaction is presented in Table 5. Samples of leather consisting of the L3-151 cultivar and prepared by the basic recipe had 5.3% protein which was lower (0.05) than that of samples from the three other treatments. The ash content at 3.0% was higher (0.05) for samples consisting of L3-151 cultivar and prepared by the basic recipe than the percentage of ash in samples from the three other treatments. Percentages of moisture, crude fat, crude fiber, and carbohydrate were not different (0.05 level) among the four treatments.

F-ratios for the analysis of variance of neutral detergent fiber analysis are presented in Table 6. Neutral detergent fiber values were affected only by cultivar at the 0.01 level.

Presented in Table 7 are mean values for neutral detergent fiber analysis. Means for neutral detergent fiber differed between L3-151 and Travis cultivars at the 0.01 level of significance. Leather of the Travis cultivar had 4.1% neutral detergent fiber while leather of the L3-151 cultivar had 3.9%.

II. THICKNESS MEASUREMENTS OF SWEET POTATO LEATHER

F-ratios for the analysis of variance of thickness measurements of sweet potato leather are presented in Table 8. Thickness measurements were affected (0.01 level) only by composition of the recipes.

TABLE 5. Means[1] for Proximate Analysis of Sweet Potato Leathers as Affected by the Cultivar x Recipe Interaction

Cultivar	Recipe[2]	
	Basic	Basic with Apple
	Moisture,%	
L3-151	6.0[a]	5.9[a]
Travis	6.3[a]	5.4[a]
	Crude Protein, %[3]	
L3-151	5.3[c]	5.8[b]
Travis	6.1[b]	6.0[b]
	Crude Fat, %[3]	
L3-151	4.7[d]	5.0[d]
Travis	4.8[d]	5.2[d]
	Ash, %[3]	
L3-151	3.0[f]	2.7[e]
Travis	2.6[e]	2.6[e]
	Crude Fiber, %[3]	
L3-151	2.1[g]	2.0[g]
Travis	2.2[g]	2.3[g]
	Carbohydrate, %[3]	
L3-151	84.9[h]	84.3[h]
Travis	84.3[h]	84.0[h]

[1]Mean of three measurements.

[2]See Table 2 for recipes.

[3]Calculated on a dry weight basis.

[a-h]Means of proximate composition for protein and ash followed by different letters are different at the 0.05 level. Means of proximate composition for moisture, fat, fiber, and carbohydrate followed by the same letter are not different at the 0.05 level.

TABLE 6. F-Ratios and Error Mean Square for Neutral Detergent Fiber Analysis of Sweet Potato Leather

Source	D.F.	F-Ratio
Total	11	--
A. Cultivar	1	18.31**
B. Recipe	1	0.31^{NS}
A X B	1	0.55^{NS}
Replication	2	0.19^{NS}
		Mean Square
Residual Error	6	0.009

**Significant at the 0.01 level.

^{NS}Not significant at the 0.05 level.

TABLE 7. Mean Values[1] for Neutral Detergent Fiber for Sweet Potato Leather

Cultivar	Recipe		Cultivar[1,2] Mean
	Basic	Basic with Apple	
	----------%----------		
L3-151	4.0[a]	3.9[a]	3.9[x]
Travis	4.2[a]	4.2[a]	4.1[y]
Recipe Mean[1,3]	4.1[m]	4.0[m]	

[1]Mean of three measurements calculated on a dry weight basis.

[2]Mean values calculated without recipe interaction (n=6).

[3]Mean values calculated without cultivar interaction (n=6).

[a]Means followed by the same letter are not significant at the 0.05 level.

[m]Means followed by the same letter are not significant at the 0.05 level.

[x-y]Means followed by different letters are significant at the 0.01 level.

TABLE 8. F-Ratios and Error Mean Square for Thickness Measurements of Sweet Potato Leather

Source	D.F.	F-Ratio
Total	11	--
A. Cultivar	1	5.92^{NS}
B. Recipe	1	13.79**
A x B	1	2.77^{NS}
Replication	2	0.61^{NS}
		Mean Square
Residual Error	6	0.000005

**Significant at the 0.01 level.

^{NS}Not significant at the 0.05 level.

Mean thickness measurements for the leather are presented in Table 9. Leathers of the basic recipe were thicker (0.01 level) than those of the basic recipe containing apple. Apple contributed sufficient moisture to the mixture to cause the leather to be 0.12 mm thinner upon dehydrating.

III. CALORIC VALUE OF SWEET POTATO LEATHER

F-ratios for the analysis of variance for gross energy determinations of sweet potato leather are presented in Table 10. None of the values was significant at the 0.05 level.

Table 11 presents the mean gross caloric values for sweet potato leathers. The mean caloric value was 4.4 kcal.

IV. DETERMINATION OF COLOR OF SWEET POTATO LEATHER

The F-ratios for the analysis of variance for color values of sweet potato leather are presented in Table 12. Hunter L values were affected (0.01 level) by cultivar, recipe, storage time, and replication. Hunter "a" values were affected (0.01 level) by cultivar, recipe, and storage time. The Hunter "a" values were affected also (0.05 level) by the interaction of cultivar x recipe x storage time. Hunter "b" values were affected by cultivar, recipe, and storage time at the 0.01 level and replication was significant at the 0.05 level.

Presented in Table 13 are the effects of the factors on Hunter color values of sweet potato leather. The color of samples

TABLE 9. Mean[1] Values for Thickness Measurements of Sweet Potato Leather

Cultivar	Recipe		Cultivar Mean[1,2]
	Basic	Basic with Apple	
	mm		
L3-151	0.96[a]	0.78[a]	0.87[x]
Travis	0.82[a]	0.75[a]	0.79[x]
Recipe Mean[1,3]	0.89[m]	0.77[n]	

[1]Mean of three replications.

[2]Mean of six values calculated without recipe interaction.

[3]Mean of six values calculated without cultivar interaction.

[a]Means followed by the same letter are not significant at the 0.05 level.

[m-n]Means followed by different letters are significant at the 0.01 level.

[x]Means followed by the same letter are not significant at the 0.05 level.

TABLE 10. F-Ratios and Error Mean Square for Gross Energy Determinations of Sweet Potato Leather

Source	D.F.	F-Ratio
Total	11	--
A. Cultivar	1	0.25^{NS}
B. Recipe	1	3.15^{NS}
A x B	1	1.13^{NS}
Replication	2	0.18^{NS}
		Mean Square
	6	0.002

^{NS}Not significant at the 0.05 level.

TABLE 11. Mean[1] Values for Gross Energy Determinations of Sweet Potato Leather

Cultivar	Recipe		Cultivar Mean[1,2]
	Basic	Basic with Apple	
	------- kcal/gm ----------		
L3-151	4.4[a]	4.4[a]	4.4[x]
Travis	4.5[a]	4.4[a]	4.4[x]
Recipe Mean[1,3]	4.4[m]	4.4[m]	

[1]Mean of three replications.

[2]Mean of six values calculated without recipe interaction.

[3]Mean of six values calculated without cultivar interaction.

[a]Means followed by the same letter are not significant at the 0.05 level.

[m]Means followed by the same letter are not significant at the 0.05 level.

[x]Means followed by the same letter are not significant at the 0.05 level.

TABLE 12. F-Ratios and Error Mean Squares for Hunter Color Values of Sweet Potato Leather

Source	D. F.	L	"a"	"b"
Total	35	--	--	--
A. Cultivar	1	38.32**	283.49**	12.32**
B. Recipe	1	246.67**	669.72**	135.46**
C. Storage	2	35.39**	68.24**	18.44**
A x B x C	7	1.78^{NS}	3.43*	1.49^{NS}
Replication	2	7.78**	2.62^{NS}	4.97*
		Mean Squares		
Residual Error	22	0.106	0.219	0.130

*Significant at 0.05 level.

**Significant at 0.01 level.

^{NS}Not significant at the 0.05 level.

TABLE 13. Effect of Cultivar, Recipe, and Storage Time on Mean[1] Hunter Color Values of Sweet Potato Leather

	L	"a"	"b"
Cultivar			
L3-151	37.74[b]	11.69[a]	19.56[b]
Travis	38.41[a]	9.07[b]	19.98[a]
Recipe			
Basic	38.93[c]	12.40[c]	20.47[c]
Basic with Apple	37.22[d]	8.36[d]	19.07[d]
Storage (days)			
0	38.69[e]	11.60[e]	20.23[e]
30	37.93[f]	10.13[f]	19.73[f]
60	37.60[f]	9.41[g]	19.34[f]

[1]Means of six measurements.

[a-g]Means within a column for each factor followed by different letters are different at the 0.01 level.

prepared from the L3-151 cultivar were darker, redder, and less yellow. The color of samples prepared from the basic recipe was lighter, redder, and more yellow.

The mean Hunter L values for the leathers during storage decreased (samples became darker) from the onset of storage to 30 days, but no change occurred after 30 days. The Hunter "a" values decreased from 11.6 at the beginning of storage to 9.4 after 60 days of storage. Consequently, the samples became less red as the storage duration was extended to 60 days. The samples became less yellow as indicated by the declining "b" values during the first 30 days of storage, but, thereafter, no change occurred. The decrease in proportion of carotene content of the sweet potatoes with the addition of apples may have contributed to the significant difference among means for Hunter L, "a" and "b" values.

Mean Hunter color values for stored sweet potato leather as affected by the cultivar x recipe x storage interaction are presented in Table 14. Statistically, differences were shown between Hunter values even though the absolute values were very small. From the subjective point of view, it is doubtful that the human eye could have discerned color differences between the samples.

V. pH MEASUREMENTS OF SWEET POTATO LEATHER

F-ratios for the analysis of variance for pH of the sweet potato leathers are presented in Table 15. pH was affected (0.01 level) by cultivar, recipe, and storage time.

TABLE 14. Mean[1] Hunter Color Values for Stored Sweet Potato Leather

Recipe	Storage, Days	Cultivar L3-151	Cultivar Travis
		L	
Basic	0	39.1[a]	40.2[a]
	30	38.3[a]	39.3[a]
	60	38.0[a]	38.6[a]
Basic with Apple	0	37.4[a]	38.0[a]
	30	36.8[a]	37.3[a]
	60	36.8[a]	37.0[a]
		"a"	
Basic	0	15.6[a]	11.6[cd]
	30	13.8[b]	10.9[d]
	60	12.4[c]	10.1[d]
Basic with Apple	0	11.0[d]	8.2[e]
	30	8.8[e]	7.0[ef]
	60	8.5[e]	6.6[f]
		"b"	
Basic	0	20.4[a]	21.5[a]
	30	20.2[a]	20.6[a]
	60	20.0[a]	20.0[a]
Basic with Apple	0	19.2[a]	19.8[a]
	30	19.0[a]	19.1[a]
	60	18.5[a]	18.8[a]

[1]Means of three measurements.

[a-f]Means within a factor followed by different letters are different at the 0.05 level.

TABLE 15. F-Ratios and Error Mean Square for pH of Sweet Potato Leather

Source	D.F.	F-Ratio
Total	35	--
A. Cultivar	1	50.18**
B. Recipe	1	434.97**
C. Storage	2	62.02**
A x B x C	7	1.14^{NS}
Replication	2	0.74^{NS}
		Mean Square
Residual Error	22	0.003

**Significant at the 0.01 level.

^{NS}Not significant at the 0.05 level.

The mean pH values of the leather are presented in Table 16. Leathers prepared from the Travis cultivar had the lower pH and leathers prepared from the basic with apple recipe had the lower pH. pH values increased over the 60 days storage period. pH values were not affected by the cultivar x recipe x storage time interaction and had a mean pH of 4.8 over the 60 day storage period.

VI. TENSILE STRENGTH OF SWEET POTATO LEATHER

F-ratios for the analysis of variance for tensile strength of sweet potato leather are presented in Table 17. Tensile strength was affected (0.01 level) by recipe and storage time but not cultivar. The interaction among cultivar, recipe, and storage time was significant at the 0.05 level.

Presented in Table 18 are the mean forces which reflect the tensile strength of sweet potato leather. Leathers prepared from the basic recipe yielded a tougher leather than leathers prepared from the basic with apple recipe. Tensile strength measurements for all leathers were significantly higher after 30 days storage. No significant change occurred between 30 and 60 days storage.

Mean tensile strength measurements of stored sweet potato leather are presented in Table 19. Tensile strength decreased (0.05) for Travis basic with apple leather stored for 30 or 60

TABLE 16. Effect of Cultivar, Recipe, and Storage Time on Mean pH Values of Sweet Potato Leather[1]

	pH
Cultivar	
L3-151	4.9[a]
Travis	4.8[b]
Recipe	
Basic	5.0[c]
Basic with Apple	4.7[d]
Storage (days)	
0	4.7[g]
30	4.8[f]
60	5.0[e]

[1]Means of six measurements.

[a-g]Means within each factor followed by different letters are different at the 0.01 level.

TABLE 17. F-Ratios and Error Mean Square for Tensile Strength of Sweet Potato Leather

Source	D.F.	F-Ratio
Total	35	--
A. Cultivar	1	0.31^{NS}
B. Recipe	1	9.06**
C. Storage	2	12.97**
A x B x C	7	3.06*
Replication	2	0.57^{NS}
		Mean Square
Residual Error	22	11.11

*Significant at the 0.05 level.

**Significant at the 0.01 level.

^{NS}Not significant at the 0.05 level.

TABLE 18. Effect of Some Experimental Factors on Mean Tensile Strength Measurements of Sweet Potato Leather[1]

	Instron Force, gms
Cultivar	
L3-151	49.2[a]
Travis	49.8[a]
Recipe	
Basic	51.2[b]
Basic with Apple	47.8[c]
Storage (days)	
0	53.5[d]
30	47.7[e]
60	47.3[e]

[1]Means of six measurements.

[a-e]Means within a factor followed by different letters are different at the 0.01 level.

TABLE 19. Mean[1] Tensile Strength Measurements of Sweet Potato Leather as Affected by the Cultivar x Recipe x Storage Time Interaction

Recipe	Storage, Days	Cultivar L3-151	Cultivar Travis
		force, gms	
Basic	0	51.5^{ab}	54.9^{a}
	30	47.2^{bc}	48.5^{abc}
	60	54.8^{a}	50.0^{ab}
Basic with Apple	0	52.4^{ab}	55.1^{a}
	30	46.2^{bc}	47.3^{bc}
	60	42.9^{c}	42.9^{c}

[1]Means of three measurements.

$^{a-c}$Means followed by different letters are different at the 0.05 level.

days. Sweet potato leathers became more brittle in texture over storage and were easier to pull apart.

VII. BACTERIAL COUNTS IN SWEET POTATO LEATHER

Presented in Table 20 are total microbial counts ($\log_{10}$) for sweet potato leather stored at room temperature. Less than $\log_{10}$ 2.0 - 2.3 colonies per gram survived dehydration. The bacterial standard plate counts for sweet potato leather of both cultivars and recipes appeared to remain approximately the same over the 60 day storage period.

Presented in Table 21 are presumptive Staphylococcus aureus counts ($\log_{10}$) for sweet potato leather stored at room temperature. Less than $\log_{10}$ 2.1 - 2.3 colonies per gram survived dehydration and no additional growth occurred over the 60 day storage period.

Total coliform counts ($\log_{10}$) for sweet potato leather stored at room temperature are presented in Table 22. Less than 10 colonies per gram could be cultured after dehydration and 60 days storage.

Presented in Table 23 are mold counts ($\log_{10}$) for sweet potato leather stored at room temperature. Less than 10 colonies per gram were cultured at 0, 30, and 60 days storage.

No microbial count was greater than 30 at the 10' dilution for total microbial count. All counts are estimated counts based on highest plate count at 10' dilution. No microbial or mold counts

TABLE 20. Total[1] Microbial Counts (Log_{10}) for Sweet Potato Leather Stored at Room Temperature[2]

Cultivar	Recipe	Days Storage		
		Counts/gm		
		0	30	60
L3-151	Basic	2.1	2.2	2.3
	Basic with Apple	2.3	2.2	2.3
Travis	Basic	2.1	2.2	2.0
	Basic with Apple	2.2	2.3	2.2

[1]Means of three replications.

[2]No microbial count was greater than 30 at the 10' dilution. All counts are estimated counts based on highest plate count at 10' dilution.

TABLE 21. Presumptive *Staphylococcus aureus* Counts[1] (Log_{10}) for Sweet Potato Leather Stored at Room Temperature[2]

Cultivar	Recipe	Days Storage		
		Counts/gm		
		0	30	60
L3-151	Basic	2.1	2.2	2.3
	Basic with Apple	2.3	2.2	2.3
Travis	Basic	2.1	2.2	2.0
	Basic with Apple	2.2	2.3	2.2

[1]Mean of three replications.

[2]No microbial count was greater than 30 at the 10' dilution. All counts are estimated counts based on highest plate count at 10' dilution.

TABLE 22. Total Coliform Counts[1] (Log_{10}) for Sweet Potato Leather Stored at Room Temperature[2]

Cultivar	Recipe	Days Storage		
		Counts/gm		
		0	30	60
L3-151	Basic	< 1	<1	<1
	Basic with Apple	< 1	<1	<1
Travis	Basic	< 1	<1	<1
	Basic with Apple	< 1	<1	<1

[1]Mean of three replications.

[2]No microbial count was greater than 10 at the 10' dilution. All counts are estimated counts based on highest plate count at 10' dilution.

TABLE 23. Mold Counts[1] (Log_{10}) for Sweet Potato Leather Stored at Room Temperature[2]

Cultivar	Recipe	Days Storage		
		Counts/gm		
		0	30	60
L3-151	Basic	<1	<1	<1
	Basic with Apple	<1	<1	<1
Travis	Basic	<1	<1	<1
	Basic with Apple	<1	<1	<1

[1]Mean of three replications.

[2]No mold count was greater than 10 at the 10' dilution. All counts are estimated counts based on highest plate count at 10' dilution.

were significant for any of the leathers. Sweet potato leather had a low moisture content and a high sugar content and did not provide an adequate environment for growth of the organisms selectively tested for in this study.

VIII. SENSORY EVALUATION

F-ratios for the analysis of variance for panel scores of quality attributes of sweet potato leather are presented in Table 24. The F-ratios for mean scores of individual panelists for chewiness, toughness, sweetness, spiciness, fruitiness, and overall acceptability were significant at the 0.01 level. Stickiness was significant at the 0.05 level. Combination (panel scores for all recipes using L3-151 and Travis cultivars) F-ratios for chewiness, toughness, and stickiness were significant at the 0.01 level; and fruitiness and overall acceptability at the 0.05 level.

F-ratios for contrast of scores of all samples of leather prepared by the basic recipes against scores of samples of leather prepared by the basic recipe containing apple were not significant for any of the attributes. F-ratios for contrast of scores for all samples prepared from 'L3-151' against scores of samples of leather prepared from 'Travis' were not significant for any of the attributes except chewiness (0.05 level).

There were no significant differences between leathers dried by the dehydrator and the kitchen oven for any of the attributes. Leathers dried in the dehydrator differed from leathers dried in

TABLE 24. F-Ratios and Error Mean Squares for Panel Scores of Quality Attributes of Sweet Potato Leather

Source	D.F.	Chewiness	Toughness	Stickiness	Sweetness	Spiciness	Fruitiness	Overall Acceptability
Total	223							
Panelist	55	2.41**	2.06**	0.04*	4.67**	4.29**	2.38**	2.59**
Combination[1]	7	14.19**	28.57**	2.80**	1.51^{NS}	1.27^{NS}	2.58*	2.08*
Contrast:								
Recipe SS[2]	1	1.15^{NS}	1.51^{NS}	0.01^{NS}	0.08^{NS}	0.02^{NS}	0.40^{NS}	1.79^{NS}
Cultivar SS[3]	1	4.13*	0.10^{NS}	2.74^{NS}	2.43^{NS}	0.55^{NS}	2.81^{NS}	1.68^{NS}
Dehydrator vs. Kitchen[4]	1	1.14^{NS}	0.60^{NS}	0.21^{NS}	0.08^{NS}	0.21^{NS}	1.90^{NS}	0.30^{NS}
Dehydrator vs. Solar[5]	1	27.88**	39.77**	4.06*	2.87^{NS}	2.28^{NS}	3.45^{NS}	3.13^{NS}
55 vs. 90[6]	1	2.79^{NS}	0.00^{NS}	5.87*	3.28^{NS}	0.02^{NS}	0.17^{NS}	1.34^{NS}
Dehydrator vs. 55[7]	1	25.47**	51.94**	0.19^{NS}	0.50^{NS}	0.10^{NS}	0.12^{NS}	0.10^{NS}
Dehydrator vs. 90[8]	1	45.12**	52.87**	8.17**	1.22^{NS}	0.21^{NS}	0.00^{NS}	1.57^{NS}
		Mean Squares						
Residual Error	161	1.17	1.26	1.76	0.84	1.06	1.27	1.40

*Significant at 0.05 level.

**Significant at 0.01 level.

^{NS}Not significant at the 0.05 level.

[1]Combination--Represents F-ratios of panelists scores for all recipes using L3-151 and Travis cultivars.

[2]Recipe SS--F-ratios of panel scores for comparison of all basic recipes with all basic with apple recipes. Had no cultivar interaction.

[3]Cultivar SS--F-ratios of panel scores for comparison of all L3-151 recipes with all Travis recipes. Had no recipe interaction.

[4]Dehydrator vs. Kitchen--F-ratios of panel scores for comparison of L3-151 basic recipe dehydrated in a forced air dehydrator with L3-151 basic recipe dehydrated in a kitchen oven.

[5]Dehydrator vs. Solar--F-ratios of panel scores for comparison of L3-151 basic recipe dehydrated in a forced air dehydrator with L3-151 basic recipe dehydrated in a solar drier.

[6]55 vs. 90--F-ratios of panel scores for comparison of L3-151 basic recipe sweetened with 55% high fructose corn syrup with L3-151 basic recipe sweetened with 90% high fructose corn syrup.

[7]Dehydrator vs. 55--F-ratios of panel scores for comparison of L3-151 basic recipe sweetened with honey with L3-151 basic recipe sweetened with 55% high fructose corn syrup.

[8]Dehydrator vs. 90--F-ratios of panel scores for comparison of L3-151 basic recipe sweetened with honey with L3-151 basic recipe sweetened with 90% high fructose corn syrup.

the solar drier in chewiness (0.01 level), toughness (0.01 level), and stickiness (0.05 level).

The use of 55% high fructose corn syrup or 90% high fructose corn syrup did not affect any of the organoleptic attributes except stickiness (0.05 level).

Contrast of scores for leathers made from 'L3-151' basic recipe containing honey as the sweetener against scores for leathers made from 'L3-151' basic recipe containing 55% high fructose corn syrup showed that the two groups of samples were different in toughness at the 0.01 level. The use of 90% high fructose corn syrup caused a difference (0.01 level) in chewiness, toughness, and stickiness of samples prepared from the 'L3-151' basic recipe

Mean panel scores of quality attributes of sweet potato leather are presented in Table 25. Mean values for chewiness ranged from 2.4 for leather made from 'L3-151' basic recipe with 905 high fructose corn syrup to 4.7 for leather made from 'L3-151' basic recipe with apple. Panel scores indicated that sweet potato leathers were moderately chewy.

Sweet potato leather recipes were judged to be tough by panelists. Scores ranged from 2.0 for leathers prepared from 'L3-151' basic recipe with 90% high fructose corn syrup to 4.9 for leather prepared from 'Travis' basic recipe. High fructose corn syrup and solar drying yielded leathers that were less tough.

Panel scores for stickiness ranged from 2.9 for leather prepared from 'L3-151' basic recipe with 90% high fructose corn

TABLE 25. Mean[1] Panel Scores of Quality Attributes of Sweet Potato Leather

Recipes	Quality Attributes						
	Chewiness[2]	Toughness[2]	Stickiness[2]	Sweetness[2]	Spiciness[2]	Fruitiness[2]	Overall Acceptability[2]
L3-151 Basic	4.4	4.3	4.1	3.6	2.7	3.2	3.6
L3-151 Basic with Apple	4.7	4.7	4.1	3.3	2.7	3.6	3.9
L3-151 Basic Kitchen Oven	4.1	4.6	3.6	3.3	2.5	2.7	3.2
L3-151 Basic Solar	3.3	2.6	3.3	2.9	2.4	2.7	2.9
L3-151 Basic with 55% HFCS	3.3	2.6	3.9	3.5	2.9	3.3	3.4
L3-151 Basic with 90% HFCS	2.4	2.0	2.9	3.2	2.8	3.0	3.0
Travis Basic	4.3	4.9	3.9	3.2	3.1	3.1	3.2
Travis Basic with Apple	3.7	4.0	3.5	3.0	2.6	2.7	3.4

[1]Mean of 28 observations.

[2]A scale of one to six was used to rate quality attributes of sweet potato leathers. One indicated the absence of a characteristic to a high degree and six indicated the presence of a characteristic to a high degree. For overall acceptability a score of one indicated "like" and a score of six indicated "dislike."

syrup to 4.1 for leather made from 'L3-151' basis recipe and basic recipe with apple. Panel scores for all sweet potato leather recipes indicated a moderately sticky texture.

Panel scores for sweetness ranged from 2.9 for leather made from 'L3-151' basic recipe solar-dried to 3.6 for leather made from 'L3-151' basic recipe. Panelists scored all leathers approximately the same for the attribute of sweetness.

Panel scores for spiciness ranged from 2.4 for leather made from 'L3-151' basic recipe solar-dried to 3.1 for leather made from 'Travis' basic recipe. Sweet potato leather recipes were not judged spicy by the panelists.

Panel scores for fruitiness ranged from 2.7 for leathers made from 'L3-151' basic recipe kitchen oven dried and 'L3-151' basic recipe solar dried and 'Travis' basic with apple to 3.6 for leathers made from 'L3-151' basic recipe containing apple. Sweet potato leather recipes were judged moderately fruity by the panelists.

Panel scores for overall acceptability ranged from 2.9 for leather made from 'L3-151' basic recipe solar-dried to 3.9 for leather made from 'L3-151' basic recipe containing apple. No sweet potato leather was totally unacceptable to the panelists. All scores were centralized on the scale of one to six indicating that no sweet potato leather was strongly disliked or liked.

IX. DRYING RATE CURVES FOR SWEET POTATO LEATHER

Presented in Figure 1 is the drying rate curve for 'L3-151' sweet potato leather prepared from the basic recipe. Initially the sweet potato leather paste contained 63.7% moisture. After one hour the moisture had decreased to 47% and within the next six hours the moisture steadily decreased to 10%. A final steady moisture level of 6.0% was attained over the final three hours.

Presented in Figure 2 is the drying rate curve for 'Travis' sweet potato leather prepared from the basic recipe. Initially the sweet potato leather paste contained 67.1% moisture. Samples of this treatment also exhibited a steady loss of moisture for the first seven hours. No significant moisture loss occurred after eight hours and the final moisture was 6.3%.

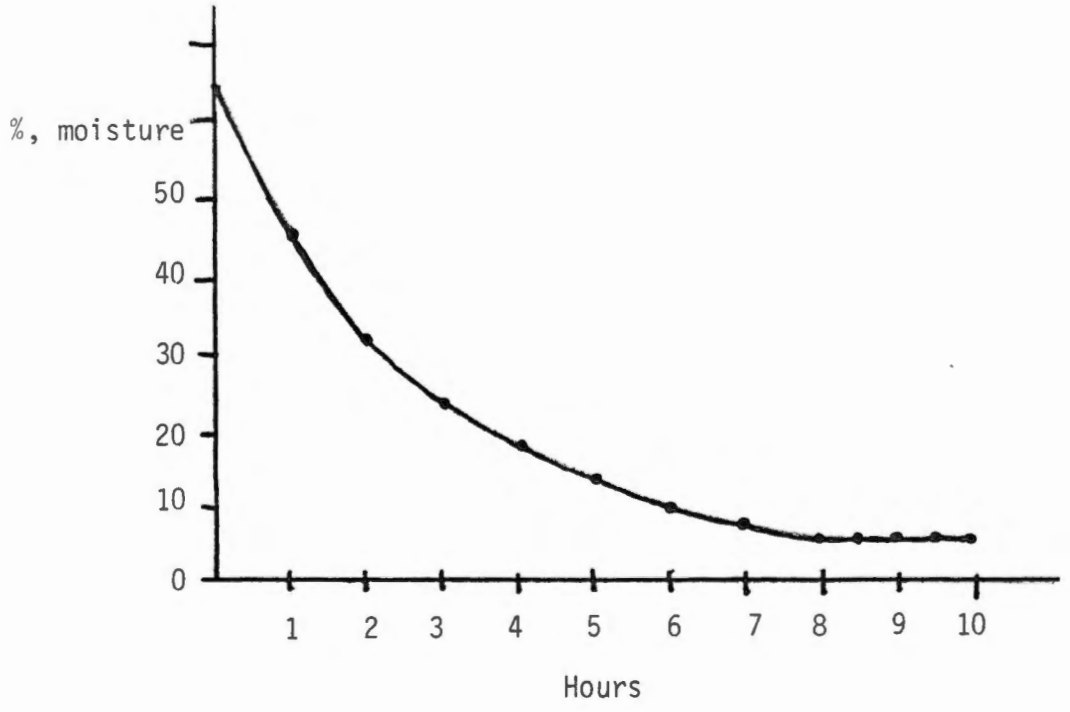

FIGURE 1. Drying rate curve for 'L3-151' sweet potato leather.

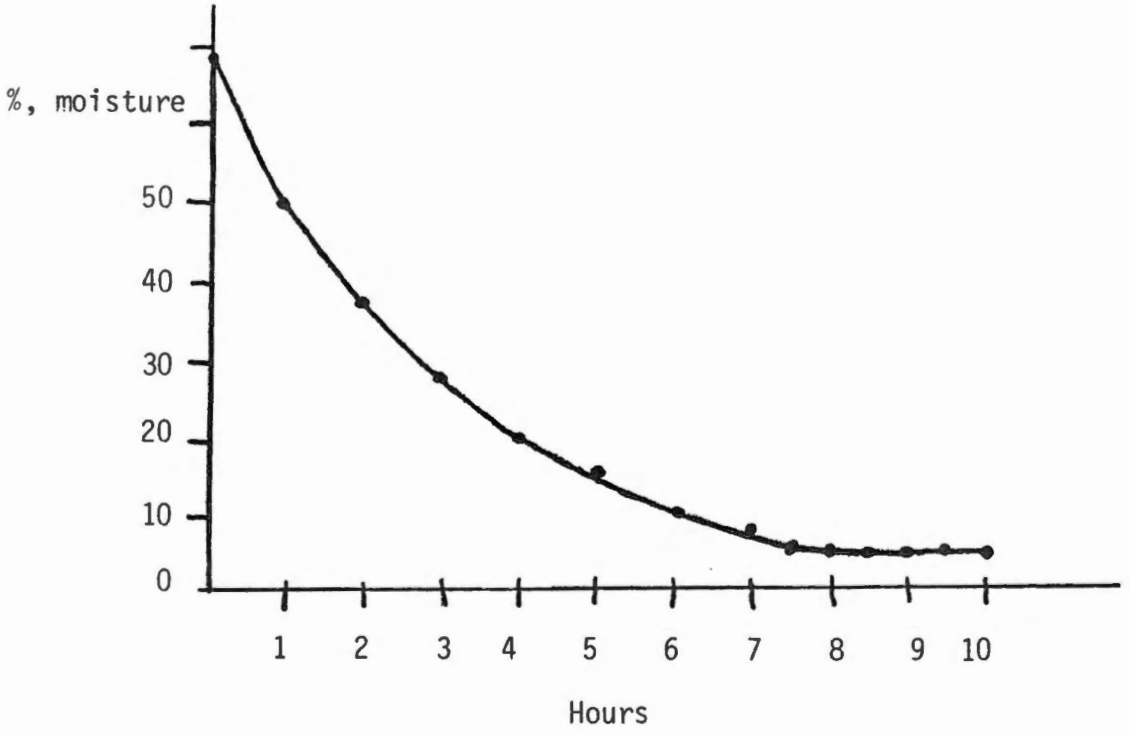

FIGURE 2. Drying rate curve for 'Travis' sweet potato leather.

CHAPTER V

SUMMARY

This study was undertaken to develop a sweet potato product (sweet potato leather) and to evaluate certain quality factors including chemical composition, physical and sensory attributes, and caloric content of the product.

Two types of sweet potato leather were prepared using two cultivars of sweet potato (L3-151 and Travis): basic sweet potato leather and basic sweet potato leather with apple. Drying rate curves were determined for the 'L3-151' and 'Travis' basic sweet potato leathers. 'Travis' basic sweet potato leather initially contained more moisture than 'L3-151' basic sweet potato leather and after drying contained a higher amount of moisture.

The proximate composition of sweet potato leathers was determined. Basic sweet potato leathers had a slightly higher moisture content (6.2%) than the basic sweet potato leathers with apple (5.7%). The addition of apple to the sweet potato leathers did not affect the composition or the caloric value.

Thickness measurements were determined for sweet potato leathers and basic sweet potato leathers prepared with apple were thinner (0.77 mm) than leathers prepared with the basic recipe (0.89 mm). Apple contributed to the thinness of the leathers.

Hunter color measurements showed that leathers prepared with the L3-151 cultivar of sweet potato were darker, redder,

and less yellow than samples prepared from the Travis cultivar. This was due to differences in sweet potato cultivars. Basic recipe leather samples were lighter, redder, and more yellow than basic recipe leathers containing apple. Addition of apple produced a darker leather.

The pH values of the leathers were close but leathers prepared from the basic recipes with apple had a lower pH than basic recipe leathers. Tensile strength of the leathers was measured and basic recipe leathers yielded a tougher leather than basic recipe with apple leathers.

Total microbial counts, presumptive Staphylococcus aureus counts, total coliform counts, and mold counts were determined on all leathers. No microbial counts were higher than $\log_{10}$ 2.3 for any leather over 60 days storage period.

The leathers were evaluated by a sensory panel for flavor, texture, and overall acceptability. Included in the taste panel samples were leathers prepared from the basic recipe and dried in a kitchen oven and a solar dryer. Also included in the taste panel were leathers prepared from the basic recipe but containing 55% and 90% high fructose corn syrup instead of honey.

Leathers dried in a forced air dehydrator were rated tougher and chewier than those dried in a solar dryer and those sweetened with 55% and 90% high sructose corn syrup. L3-151 leathers were chewier than 'Travis' leathers. Dehydrator-dried leathers were

rated stickier than those leathers dried in a solar dryer. Basic sweet potato leathers prepared with 55% high fructose corn syrup were stickier than those prepared with 90% high fructose corn syrup.

This study shows that acceptable sweet potato leathers can be prepared by various drying methods and recipes. Ease of preparation and storage indicates that additional studies could be conducted to produce a marketable sweet potato product.

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