THE UNIVERSITY OF MANITOBA

A Study of the Effects of Certain Agronomic Factors Upon the Chemical Composition and Chipping Quality of Certain Varieties of *Solanum tuberosum* L

by

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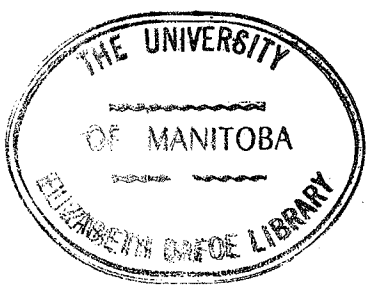
A Thesis

Submitted to the Faculty of Graduate Studies
In partial fulfillment of the requirements for the
Degree of Master of Science

Department of Food Science

Winnipeg, Manitoba

February, 1971



ABSTRACT

A Study of the Effects of Certain Agronomic Factors Upon the Chemical Composition and Chipping Quality of Certain Varieties of Solanum tuberosum L

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Reducing sugar content alone does not always provide a suitable index in the prediction of color in potato chips. Studies were conducted on the effects of varieties, storage conditions, and fertilizer treatments on the reducing sugar, soluble iron, total nitrogen and total phenolic content of the potato tuber. An attempt was made to use these interrelationships in predicting the chipping quality of tubers for processing.

ACKNOWLEDGEMENTS

I wish to thank my supervisor, Dr. M.B. McConnell, and the other members of my committee, Dr. P.E. Cansfield, Dr. K.W. Clark and Dr. R.A. Gallop for their help throughout the course of this study.

I wish to express my sincere appreciation to Dr. M. Birecki and Prof. J.A. Menzies for providing the potato samples used in the experimental work.

Thanks are also due to Misses Cheryl M. Cringan, Linda D. James, Elizabeth M. McKerlie and Mr. G.J. Gerbasi for their help in the sample preparation and chemical analyses. I am grateful for technical assistance by Messrs. R.J. Buchanan, A.E. Krentz, R.H. Mogan and K.F. Zutrum.

I also wish to express my sincere appreciation to Dr. B. Johnston for his interest and assistance in the statistical aspects of this study. Thanks are due to Messrs. W.H. Doran and B.G. Wiebe for their help in developing the required computer programs. I wish to thank Mr. H.J.C. Nottelmann for his interest and assistance in the development of Appendices IV-VIII.

I am indebted to Mrs. Irene Hamel for the typing of this manuscript.

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I INTRODUCTION

The common potato, Solanum tuberosum L., is rapidly gaining popularity as a source of income for the agricultural sector of the Province of Manitoba. In 1969 of the 29,000 acres planted, 2,225 acres were grown for seed, 8,500 acres for the fresh market and 18,275 acres for processing. The average yield, 218.3 bushels per acre, was sold at an average price of $1.15 per bushel giving the farmer a gross return of $251.62 per acre (16). It is interesting to note that although the acreage in potatoes was only 0.33% of the total acreage for agricultural crops in Manitoba, the gross return from this acreage was 2.65% of the total farm value in 1969. Although the fresh market and certified seed requirements have remained static for the past few years, increased production of processed potato products by local processors has led to additional requests for potatoes of processing quality. This requirement is partially met by a larger acreage which has been increasing by approximately 2,500 acres for each of the past few years (16).

The potato processors are making special demands for quality potatoes. Chip color and yield, as product, are of paramount importance to the chip manufacturers. Proper selection of varieties and careful handling are the keys to high processing quality. Since only limited quantities of the potatoes are processed immediately after harvest, adherence to proper storage management techniques is most important.

Unfortunately high yield per acre and high quality do not correlate as well as might be expected. Although mineral fertilizers may increase yield per acre, the improper use of these may result in poorer quality. One of the more important minerals is potassium, which is essential in the synthesis of simple sugars and starch. The potato, being largely a starch producing plant, has high requirements for this nutrient.

During the summer of 1968 potato samples with a low reducing sugar content were obtained from several local growers who reported that even though these potatoes contained only low levels of reducing sugars, the color of the potato chips made from them was unacceptable. Some factors other than reducing sugar were obviously determining product color.

Since the method of determining whether or not a sound lot of chipping potatoes should be accepted is usually made on the basis of reducing sugar content alone, an introductory study was carried out to develop a more efficient means of prediction of chip color. By employing a model system as used previously at the Morden Experimental Station, in which filter papers were dipped in solutions of a selection of potato constituents as pure chemicals, and under similar conditions as for chips, it was confirmed that color was not produced by reducing or non-reducing sugars alone, but rather by a combination of reducing sugars, amino acids, phenolic type compounds, and soluble iron salts. Preliminary observations of the chemical composition of the potato

tubers in question seemed to present similar results. Both studies suggested that further investigations were warranted.

The present study was to determine the chemical composition and chipping quality (determined by color) of potato tubers. Five varieties of potatoes were grown with three levels of potassium fertilizer at two locations. The potatoes, after being harvested, were stored at two temperatures for three storage periods varying in length from two to six months.

II REVIEW OF LITERATURE

Potato chips are a high energy food produced by the rapid dehydration of potato slices in direct contact with hot fat at temperatures ranging from 325 - 375°F. During dehydration fat is absorbed by the chips. This fat and the addition of 1.0 to 2.75% salt adds to the flavor and nutritive value of the potato chips, which are now the most widely used ready-to-eat processed potato product (3).

Color is one of the most important attributes of quality in potato chips. The chemical composition of the tuber greatly influences chip color. Browning of potato chips has generally been attributed to the caramelization of the reducing sugars by the hot frying fat but more recent research has shown that browning of chips is largely due to a Maillard type reaction between reducing sugars and amino acids (10).

Since the pigments responsible for the color of the potato chips are formed as a result of chemical reactions that take place during frying, the rate and extent of their formation would depend upon several factors. Most important of these are the relative amounts and type of reactants found in different potatoes. The potato variety selected may determine the magnitude of these factors (10).

2.1 Reducing Sugar Content

Various reports indicate that the sugar contents of potatoes may vary from trace amounts to as much as ten percent of the dry weight of the tuber (2). Although there

are many types of sugars present in potatoes, Schwimmer et al. (20) have shown that sucrose, glucose and fructose are the major sugars present in the tubers. Watada and Kunkel (24) reported that varieties differed greatly in the amount of reducing sugar accumulated and in their ability to change reducing sugars back to starch after accumulation.

The frequently observed good correlation between high reducing sugar content and dark chip color have long been a guideline for the purchasing of processing potatoes, but Yamaguchi et al. (28) claim that tubers with a low reducing sugar content and high sucrose content may not necessarily produce potato chips of attractive color.

Because of inherent varietal differences, it is very difficult to decide at which storage temperature the most sugars are likely to accumulate. Potatoes stored at 50° to 60°F are usually most satisfactory for chips; at storage temperatures of 40° or less the products are often undesirable (26). Recent high invertase inhibitor type varieties, such as Norchip, can be stored at 40 to 45°F without rapid accumulation of reducing sugars.

The trend today is to breed potatoes that will maintain low reducing sugar levels even when stored at 40°F. When this is not feasible, the potatoes can be reconditioned at temperatures around 70°F to lower the reducing sugar content sufficiently to produce chips of a desirable color (13).

2.2 Amino Nitrogen Content

The non-enzymatic browning reaction first proposed

by Maillard is generally accepted as the chief contributor towards potato chip color. In this reaction, carbohydrates with a free carbonyl group can combine with amino compounds in accordance with the aldol condensation reaction to form a N-substituted glycosylamine which, through several intermediate steps, undergoes the Strecker degradation reaction to give the brownish chip color (27).

Varieties with good chipping characteristics have usually been found to contain relatively less free amino acids than varieties which produced dark colored chips. Storage at 40°F had relatively little effect on the free amino nitrogen content; however, it gradually decreased during a following four weeks of reconditioning at 70°F (9). Using paper chromatography, the same authors (10) found that the basic amino acids, lysine, histidine and arginine, disappeared rapidly during reconditioning of tubers. They concluded that in general, low basic amino acids and low reducing sugars, particularly pentose sugars, are associated with light colored potato chips.

Schwimmer and Burr (21) suggested that the total nitrogen content of potatoes ranged from one to two percent. Lampitt and Goldenburg (14) reported average variations between 1.66 to 2.62% while Neuberger and Sanger (18) reported a variation between 1.16 to 1.95%.

2.3 Total Phenols and Soluble Iron Content

Hoover and Xander (12) found a significant correlation between total phenols and potato chip color. The total

phenols in potatoes are generally of six types: lignin, coumarins, anthocyanins and flavones, tannins, monohydric phenols, and polyphenols (21).

Cheng and Hanning (4) reported no correlation between the tannin content of the tuber and the color of the chips. Clark et al. (5) reported that the tyrosine content in the tuber was 0.1 to 0.3% of the dry weight, while the chlorogenic acid content varied between 0.025 to 0.150% of the dry weight. The phenolic content of the tubers was significantly higher in Ontario and Pontiac potatoes when stored at 40°F than when stored at 50°F (17).

One of the functions of chlorogenic acid and other polyphenols of potatoes may be their involvement in controlling the metabolism of starch (21). Henderson (11) reported that an increase in the high natural levels of chlorogenic acid in the potato tuber would not prevent the accumulation of reducing sugars during storage.

Lampitt and Goldenberg (14) reported an iron content of potato tubers ranging from 2.61 to 18.5 mg/100 gm, calculated on a dry basis.

2.4 Application of Potassium Fertilizer

Barber and Humbert (1) have suggested that the physiological functions of potassium in the plant are:

1) its influence on carbohydrate metabolism or formation,

2) its influence on the nitrogen metabolism and synthesis of protein in green plants,

3) its control and regulation of the activities of various essential mineral nutrients,

4) its neutralizing the physiologically important organic acids,

5) as an activator of various enzymes, e.g. K-activated pyruvic kinase which is responsible for the transformation of carbohydrate intermediates,

6) to promote the growth of young meristem,

7) to adjust stomatal movement and water relationships.

From these functions, one can conclude that potassium is indeed an essential nutrient for plant growth and development. Potatoes from potassium-deficient plants may be smaller in size, unshapely and may rot more quickly in storage. A potato crop yielding 3,600 lbs. tubers per acre would remove 105 lbs. K_2O per acre, while the vines would remove 120 lbs. K_2O per acre (1). It would seem that potassium increases the size of the root system allowing the roots to get more water from the soil. This would help prevent the leaves from drying out quickly. The longer the leaves are functional, the larger we may expect the tubers to be in a normally maturing crop, since the products of photosynthesis by the leaves are conveyed to the tubers, which act as storage organs.

Ward (22) indicated that the growth and development of potatoes is directly proportional to the amount of potassium applied. Although fertilizer application is used primarily for yield increase, the proper application of fertilizers may produce higher quality tubers. Eastwood and

Watts (7) reported that higher levels of potassium tended to improve chip color.

III METHODS AND MATERIALS

3.1 Field Experiment

3.1.1 Introduction In the present study, the effects of potassium fertilizer were studied at 60, 120, and 180 lbs. of potash per acre. Five varieties of Solanum tuberosum L. were considered in this study: Netted Gem, Norland, Kennebec, Pontiac and Viking. The potatoes were grown on the farm of A & M Potato Growers at Carberry. The Department of Plant Science, University of Manitoba assumed complete responsibility for the planting, cultivation and harvesting of the potato crop in this field. It was through their co-operation that the potato samples were obtained.

3.1.2 Design of Field Experiment The field experiment was designed as a split-split plot with two locations, each of which were whole plots and each of which were of the same soil type, Wellwood clay loam, and which were on the same field. The three levels of potassium were designated as the sub-plots and the five varieties were the sub-sub-plots. The experiment was designed with four replicates, of which Replicates I and III were used for the study. Thus this design consisted of 30 different treatments with two replicates giving 60 lots of potatoes. The remaining two replicates were dealt with by the Department of Plant Science.

3.1.3 Sampling The potatoes were harvested and brought into a 10°C storage room. Six samples were drawn from each lot, three of which were stored at 4.5°C and three at 10°C.

Table I gives the storage conditions under which the tubers were held.

TABLE I

STORAGE CONDITIONS OF POTATO TUBERS

Condition	Date of Sample Preparation	Temperature
1	December 1, 1969	10°C (50°F)
2	February 1, 1970	4.5°C (40°F)
3	February 1, 1970	10°C (50°F)
4	April 1, 1970	4.5°C (40°F)
5	April 1, 1970	10°C (50°F) samples sprouted
6	April 1, 1970	4.5°C conditioned at 20°C for 3 weeks

3.2 Laboratory Studies

3.2.1 Sample Preparation After each storage interval, the samples of the 60 lots stored under the appropriate temperature conditions were brought into the processing lab. Each sample was scrubbed in clean water with a nylon bristled brush and allowed to dry. The order in which the samples were handled was determined at random.

A "Hobart" Model 410 slicer, constructed with stainless steel blade and chassis, was used to obtain the potato slices. Six median longitudinal slices, each 0.05 inches in thickness, were removed from each potato in the sample. Previous work in the Department of Food Science (25) had shown that the taking of median longitudinal slices was optimal in obtaining a representative sample of the potato tuber. Three of the slices were set aside on white cheesecloth for freezing in liquid nitrogen and three slices were

set aside for blanching.

After all the slices of a particular sample had been taken, those to be frozen were placed in a piece of cheesecloth and immersed in a six-liter Dewar flask half filled with liquid nitrogen. Upon cessation of vigorous gas evolution, the sample was removed from the container, placed in two layers of cheesecloth and pulverized with a rubber mallet. The pulverized samples were held under frozen storage conditions at -20°F in properly labelled and sealed plastic bags.

3.2.2 Chip Frying and Color Measurement The portion of the slices set aside for blanching was steam blanched for five minutes in a 25 gallon "Groen" open steam-jacketed kettle. The sample was washed in cold water to remove excess starch and dried between white paper towels. One hundred grams of the slices were fried at maximum temperature (Table II) for three minutes on a model 80-03 "Garland" fryer filled with approximately 25 lbs. of "Fryene" cooking fat. The chips were allowed to drain on paper towels. The drained chips were then placed in a plastic bag, pulverized into a fine powder and labelled.

Upon completion of each sampling period, the chip color of each series of samples was read on a Model D25 "Hunterlab" Color-Difference Meter using a white standard tile with the following values as a reference: L = 93.8, a = -1.1, b = +2.3.

Since one of the more objective color measurements

on potato chips is the L value (9), it was decided that L values should be used to measure chip color.

Frying conditions were kept as uniform as possible. The cooking fat was replaced after frying 60 samples. A constant temperature check was maintained on the Garland fryer using a "Thermoelectric" Multipoint Recorder with two thermocouples placed approximately one-half inch below the bottom surface of the basket. Average frying temperatures for the first 30 samples of the second storage period are given in Table II.

TABLE II

AVERAGE FRYING TEMPERATURE OF POTATO CHIPS

Time in Sec. from Immersion of Sample	Temperature °C
0	192.1 ± 1.6
30	185.5 ± 1.7
60	186.2 ± 1.6
90	188.3 ± 2.0
120	191.3 ± 1.5
150	192.1 ± 1.6
180	192.1 ± 1.6

An analysis of variance on the same data has shown significant differences between samples at the 1% level. (Appendix 3) However, the variation from highest to lowest mean frying temperature was considered to be less than that experienced in the potato chip industry. Therefore this factor was not considered as likely to interfere in the analysis of the color measurements.

3.2.3 Determination of Dry Matter Each sample dish was dried for one hour in a hot air oven at 100°C and cooled in a vacuum desiccator containing anhydrous calcium chloride. When cooled, the sample dish was weighed on a "Sartorius" Model 2462 analytical balance. Approximately 10 grams of the frozen potato tissue were added to the sample dish and the sample dish was weighed to obtain the actual weight of the sample. Since an analysis of variance on data obtained in preliminary studies indicated that no significant loss of weight had occurred due to respiration, the sample was allowed to air dry for several hours. The sample was then hot-air dried at 70°C to constant weight, cooled in the vacuum desiccator, and weighed to obtain the weight of the dried potato tissue.

3.2.4 Preparation of Sample Extract Literature reviews tended to indicate that alcohol-soluble extracts could be used for the determination of three of the four chemical components mentioned.

The method of analysis proposed by Folin and Ciocalteu (8) suggested the use of alcohol-soluble extracts. LeTourneau (15) reported that the three major sugars in the tuber, glucose, fructose and sucrose, were alcohol-soluble. Yates and Hallsworth (29) suggested the use of alcohol-soluble extracts for the determination of nitrogenous compounds.

3.2.4.1 Reagents 1. Ethyl alcohol 60% v/v in ammonia-free water (Appendix I).

3.2.4.2 Method A preliminary study with various mixtures of ethyl alcohol and ammonia-free water indicated that ethyl alcohol (60% v/v) was an effective medium for the extraction of the total phenols, total reducing sugars, total soluble iron and the total aqueous-soluble nitrogenous compounds from the tubers.

A known weight of the frozen potato sample was suspended in approximately 50 ml of the hot alcohol solution and placed in a 125 ml Erlenmeyer flask. To prevent oxidation of the phenolic compounds to the related quinone form, nitrogen gas was bubbled through the contents of each flask to displace air. The flasks were then capped with Parafilm and stored at room temperature for 48 hours.

Previous studies indicated that this period of time was adequate for the removal of the chemical components in question.

Each sample was poured into a large centrifuge tube. The flask was washed several times with the alcohol solution and the washings were added to the tube. The sample was centrifuged on a "Sorvall" Model GLC-1 centrifuge at 2500 revolutions per minute (rpm) for 10 minutes to sediment the potato tissue. The supernatant was transferred to a 250 ml round-bottom evaporating flask and evaporated to dryness on a Buchler rotary-flask evaporator using a 20°C water bath. The flask was flushed with nitrogen gas and capped with Parafilm until required for the phenol analyses.

3.2.5 Determination of Total Phenols

The method used for the determination of total phenols

was a modification of the method proposed by Folin and Ciocalteu (8).

3.2.5.1 Reagents 1. Folin-Ciocalteu reagent: The prepared reagent, obtained from British Drug Houses - Canada, was diluted with two volumes of distilled water and stored in a dark bottle in a refrigerator. Fresh batches were made for each series of samples.

2. Silver lactate solution: Silver nitrate (2.589 gm) and sodium hydroxide (0.6096 gm) were dissolved in water, mixed, heated gently and filtered. The residual silver oxide was dissolved in lactic acid (1.356 gm) to give 3 gm of silver lactate. This procedure was adopted because the compound was not available commercially. The silver lactate was then dissolved in 97 ml of 3% lactic acid.

3. Sodium chloride/hydrochloric acid solution: To a saturated solution of sodium chloride in water, concentrated hydrochloric acid was added (10 ml acid/1000 ml solution).

4. Sodium carbonate solution: 20% w/v reagent grade sodium carbonate in distilled water.

3.2.5.2 Method The dried residue in the round bottom flask was dispersed in ammonia-free water (Appendix I) and transferred, with washing, to a 100 ml volumetric flask and the volumetric flask was made up to volume with ammonia-free water. A 10 ml aliquot of the sample was placed into a 25 ml centrifuge tube. Since the method will also detect tyrosine residues in protein, it was necessary

to remove the protein bound tyrosine. If the protein is not removed it tends to precipitate out during the determination. It was removed as the silver complex by the addition of 1.5 ml silver lactate solution.

After the solution was allowed to stand 20 minutes, 1.5 ml of the sodium chloride/hydrochloric acid solution was added to precipitate excess silver ions, and the tube was centrifuged at 2500 rpm for 10 minutes on the centrifuge.

Ten ml of the supernatant was transferred to a 50 ml volumetric flask and the flask was made up to volume with distilled water. A 10 ml aliquot was placed into a large test tube, to which 0.5 ml Folin-Ciacalteau reagent and 2 ml sodium carbonate solution were added. The contents of the tube were mixed, allowed to stand 20 seconds, capped with a loose glass stopper and placed in a vigorously boiling water bath (Appendix II) for exactly one minute. The tube was removed from the water bath, allowed to stand for one minute and cooled under cold tap water. The optical density of the solution was determined at a wavelength of 765 nanometers (nm) on a "Bausch and Lomb" Spectronic 20 spectrophotometer, using distilled water as a blank. The concentration of total phenols, expressed as percent catechol on a dry weight basis, was determined from a previously prepared calibration graph.

3.2.6 Determination of Total Reducing Sugar (19)

3.2.6.1 Reagents 1. Dinitrophenol reagent: Sodium 2-4 dinitrophenolate (8 gm) and phenol (2.5 gm) were dissolved in 200 ml of 5% sodium hydroxide (w/v). Sodium

potassium tartrate (100 gm) was dissolved in 500 ml distilled water. The two solutions were mixed, transferred to a one litre volumetric flask and made up to volume with distilled water.

3.2.6.2 Method A 2 ml aliquot of the sample extract prepared for the phenol test and 6 ml of the reagent were placed in a large test tube, mixed and heated on a boiling water bath (Appendix II) for exactly six minutes and the optical density was determined immediately on the Spectronic 20 unit at 625 nm using distilled water as a blank. The concentration of total reducing sugars, expressed as percent glucose per unit dry weight, was determined from a previously prepared calibration graph.

3.2.7 Determination of Aqueous Alcohol-Soluble Nitrogenous Compounds The method used in this study for the determination of aqueous alcohol-soluble nitrogen was a modification of the method proposed by Conway (6).

3.2.7.1 Reagents 1. Digestion mixture: concentrated sulphuric acid was diluted with three volumes ammonia-free water. Mercuric oxide (6.25 gm/1000 ml solution) was added to the resultant solution and mixed.

2. Potassium sulphate solution: 0.01% w/v in ammonia-free water.

3. Diffusion mixture: 10% sodium thiosulphate w/v in 60% w/v (in ammonia-free water) potassium hydroxide.

4. Hydrochloric acid: 0.01 N.

5. Nessler's reagent: Mercuric Iodide (50 gm) and Potassium Iodide (35 gm) were dissolved in a small amount of ammonia-free water. This mixture was added to 250 ml of 32% w/v (in ammonia-free water) sodium hydroxide. The solution was transferred to a 500 ml volumetric flask, made up to volume with ammonia-free water, and stored in a dark bottle in a refrigerator.

3.2.7.2 Special Apparatus: 1. Conway microdiffusion units: the units had an outer well diameter of 71 mm and an inner well diameter of 40 mm. The units had properly fitting ground glass covers (80 mm square).

3.2.7.3 Method A 2 ml aliquot of the sample extract prepared for the phenol test was transferred to a 30 ml Kjeldahl flask. One ml of the digestion mixture was added to the flask and the flask was heated on a micro-Kjeldahl digestion rack until the water had evaporated. Under the conditions of the digestion, organic nitrogen (mainly amino or amide N) was converted to ammonium sulphate or ammonium hydrogen sulphate.

$$\text{organic N} + H_2SO_4 \xrightarrow[HgO]{} CO_2 + H_2O + NH_4HSO_4$$

One ml 0.01% potassium sulphate solution was added to the Kjeldahl flask to increase the boiling point of the digestion mixture. The solution was digested for approximately 40 minutes until the solution was colorless. The Kjeldahl flask was cooled and washed repeatedly with small amounts of ammonia-free water. The contents were transferred to a 25 ml volumetric flask and the flask was made up to volume

with ammonia-free water.

The cover of the Conway unit was smeared evenly with silicone stopcock grease. A 2 ml aliquot of the digest was placed into the outer well and the unit was slightly tilted. Hydrochloric acid (1 ml) was placed in the inner well to convert the ammonia liberated to ammonium chloride. The unit was then partly covered and the diffusion mixture (1 ml) was added with a fast flow pipette. The unit was quickly covered, placed on a flat bench and allowed to stand for three hours. The potassium hydroxide in the diffusion mixture makes the digest strongly alkaline thus releasing ammonia. The thiosulphate caused the decomposition of ammonia-mercury complexes which might otherwise produce low results.

After the diffusion period, the lid of the unit was removed and ammonia-free water (8 ml) was added to the centre well. The dish was swirled to mix the added water and contents of the centre well. The contents of the centre well were transferred to a 25 ml volumetric flask using a fine-tipped transfer pipette. The centre well was given a wash with a further 8 ml of ammonia-free water and the washings were added to the 25 ml volumetric flask. This washing treatment was sufficient to transfer ammonium chloride practically quantitatively from the Conway unit to the flask. Nessler's reagent (0.25 ml) was added to the flask and the flask was made up to volume using ammonia-free water. The flask was allowed to stand for 10 minutes to let the reaction between the reagent and the ammonium chloride

take place. The optical density of the contents of the flask was determined at 410 nm on the Spectronic 20 unit using a 1% Nessler's reagent solution as the blank. The concentration of aqueous alcohol-soluble nitrogen, expressed as percent nitrogen per unit dry weight, was determined from a previously prepared calibration graph.

3.2.8 Determination of Total Soluble Iron (23)

3.2.8.1 Reagents 1. Iso-amyl alcohol

2. Concentrated nitric acid

3. Potassium thiocyanate solution: 20% w/v in distilled water.

3.2.8.2 Method A 20 ml aliquot of the sample extract prepared for the phenol test was placed into a large test tube. The ferrous iron was oxidized to ferric iron by the addition of concentrated nitric acid (4 drops) and by subsequent heating of the sample in a boiling water bath (Appendix II) for approximately forty minutes. The sample was cooled and transferred to a 125 ml pear-shaped separatory funnel. Iso-amyl alcohol (10 ml) and thiocyanate solution (5 ml) were added; the funnel was capped, shaken about 60 times and allowed to stand for five minutes. This caused the potassium ion to be exchanged with the ferric ion giving red ferric thiocyanate, which was taken up by the isoamyl alcohol. The colorless aqueous layer was discarded. The alcohol layer was filtered through dry filter paper and the optical density was read on the Spectronic 20 unit at 490 nm using clear iso-amyl alcohol as a blank. The concentration of total soluble iron, expressed as percent iron per

unit dry weight, was determined from a previously prepared calibration graph.

IV RESULTS AND DISCUSSION

4.1 Method of Data Collection

The data analysis was carried out on the University of Manitoba's IBM 360/65 system. All calculations were done in single precision arithmetic. Wherever possible, the IBM Scientific Subroutine package was used in writing the Fortran programs necessary for the computation of the required data. Since the calculations were done in binary mode, a certain amount of rounding error may be present in the results. Whenever possible, this was kept to a minimum.

The input data for each sample, containing values for sample weight, dry matter content, potato chip color and absorbancy readings for reducing sugars, total phenols, soluble iron and aqueous alcohol-soluble nitrogenous compounds, were used to calculate the percent chemical composition based on dry weight. These values were used to create sequential data sets on a model 2314 disk which were then used for the analyses of variance, correlation and multiple regression.

A summary of the chemical composition of the potato tubers and the corresponding potato chip color is given in Appendices IV to VIII. These values were used in all other necessary calculations.

4.2 Reducing Sugars

Average reducing sugar content (Table III) ranged from 0.627 gm/100 gm dry potato tissue to 7.2 gm/100 gm dry potato tissue. These values agree with that reported by Barker (2).

TABLE III

AVERAGE REDUCING SUGARS IN EXPERIMENTAL POTATOES*

Variety	Storage Conditions						Variety Mean
	10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C** Apr.1/70	
Netted Gem	1.303	3.115	0.860	2.100	0.795	0.887***	1.510
Kennebec	1.038	3.768	0.721	2.521	0.627	1.221***	1.650
Norland	1.035	4.592	0.919	3.291	0.743	1.558***	2.023
Pontiac	2.697	7.200	1.800	4.538	2.075	2.340***	3.442
Viking	2.944	4.953	1.531	3.648	1.489	1.880***	2.741
Storage Condition Mean	1.803	4.726	1.166	3.220	1.146	1.577	2.273

* Expressed as gm glucose/100 gm dry potato tissue.

** Storage temperature and date of sample preparation.

***Conditioned at 20°C for three weeks.

An analysis of variance on the reducing sugar content (Appendix IX) shows significant differences at the 1% level among varieties, among storage conditions and among the variety X storage condition interactions. No differences were found in the reducing sugar content between the Netted Gem and Kennebec varieties. Differences in the reducing sugar content between Norland and Netted Gem varieties were significant at the 5% level. Pontiac and Viking varieties were higher in reducing sugar content than the other three varieties. In this study, Pontiac potatoes accumulated more reducing sugars than other varieties under the same conditions. Although no significant differences were found among fertilizer levels, Barker (2) found that fertilizer levels have an effect on carbohydrate metabolism. Potato tubers stored at 40°F were significantly higher in reducing sugar content than those stored at 50°F. These results are in agreement with those reported in previous literature (26).

The analysis of variance indicated that the tubers stored at 40°F and sampled on February 1, were significantly higher in reducing sugar content than the tubers sampled on April 1 and stored at the same temperature. This would seem to contradict what one would normally expect since the sugar accumulation at 40°F should be greater for a longer storage period. However since tubers stored at 50°F showed signs of sprouting the physiology of the tubers at this sampling period is in doubt. Although the 40°F samples did exhibit signs of sprouting, the dormancy period may have been broken and it would not be possible to state the level of reducing sugar that

might be expected.

Reconditioning temperatures around 70°F are quite feasible (13). The data suggests that certain varieties can convert sugars to starch more quickly than others during similar reconditioning periods.

4.3 Aqueous Alcohol-Soluble Nitrogenous Compounds

Average nitrogenous contents (Table IV) of the potato tubers ranged from 0.5 gm/100gm dry potato tissue to 1.3 gm/100 gm dry potato tissue. These results are similar to those reported in the literature (14, 18, 21).

The analysis of variance (Appendix X) shows significant differences at the 1% level among storage conditions and among the storage condition X variety interactions. Significance at the 5% level was found among varieties and among the location X storage condition interactions. Although the literature (9, 10) suggests that larger amounts of basic amino acids may be present in potatoes of poorer chipping quality, the Netted Gem tubers contained significantly higher amounts of nitrogenous compounds (0.733%) than tubers of the Pontiac variety (0.707%). Because of the small experimental error involved it is unlikely that the data are meaningful in an agronomic sense.

Habib and Brown (9) suggest that storage at 40°F has no effect on the free amino acid content. The potato tubers stored at 40°F and sampled on April 1, 1970 had a significantly higher nitrogenous content than the corresponding tubers stored at 50°F.

TABLE IV

AVERAGE AQUEOUS ALCOHOL SOLUBLE NITROGENOUS COMPOUNDS IN EXPERIMENTAL POTATOES*

Variety	Storage Conditions						Variety Mean
	10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C** Apr.1/70	
Netted Gem	0.693	0.598	0.620	0.689	0.501	1.297***	0.733
Kennebec	0.584	0.630	0.635	0.656	0.633	0.697***	0.639
Norland	0.725	0.709	0.958	0.788	0.523	0.708***	0.734
Pontiac	0.633	0.708	0.589	0.812	0.652	0.847***	0.707
Viking	0.615	0.655	0.517	0.803	0.704	0.887***	0.702
Storage Condition Mean	0.650	0.660	0.663	0.750	0.603	0.887	0.702

* Expressed as gm nitrogen/100 gm dry potato tissue.

** Storage temperature and date of sample preparation.

***Conditioned at 20°C for three weeks.

It seems that further studies should be directed towards certain groups of amino acids rather than nitrogenous compounds as a whole, if a better understanding of these problems is to be obtained.

4.4 Total Phenols

The average total phenol content varied from 0.1 gm/100 gm dry potato tissue to 0.2 gm/100 gm dry potato tissue (Table V). Wilson (25) found that the average total phenol content was approximately 0.6 gm/100 gm based on dry weight.

Wilson used the same extraction method but her samples were taken from the 1968 crop. Since preliminary studies yielded the same phenolic contents as those obtained by Wilson, the discrepancy in this years lower values must be due to different cultural and agronomic features, rather than technique.

No significant differences among treatments were obtained from the analysis of variance (Appendix XI).

4.5 Soluble Iron

Average iron content of the potato tubers (Table VI) was approximately 2 mg/100 gm based on dry tuber weight. Although this is at the lower extreme value cited in the literature (14), cultural practices and soil condition may account for the discrepancy.

The analysis of variance (Appendix XII) revealed significant differences at the 1% level among storage conditions. These results may suggest that solubility of iron within the tuber changes with respect to length of storage.

TABLE V

AVERAGE TOTAL PHENOLS IN EXPERIMENTAL POTATOES*

Variety	Storage Conditions						Variety Mean
	10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C** Apr.1/70	
Netted Gem	0.127	0.110	0.116	0.114	0.116	0.104***	0.115
Kennebec	0.095	0.107	0.104	0.102	0.130	0.111***	0.108
Norland	0.102	0.126	0.183	0.114	0.123	0.103***	0.125
Pontiac	0.098	0.106	0.108	0.111	0.118	0.109***	0.108
Viking	0.106	0.104	0.098	0.112	0.101	0.108***	0.105
Storage Condition Mean	0.106	0.111	0.122	0.111	0.118	0.107	0.112

* Expressed as gm catechol/100 gm dry potato tissue.

** Storage temperature and date of sample preparation.

***Conditioned at 20°C for three weeks.

TABLE VI

AVERAGE SOLUBLE IRON CONTENT OF EXPERIMENTAL POTATOES*

Variety	Storage Conditions						Variety Mean
	10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C** Apr.1/70	
Netted Gem	2.25	2.13	1.86	2.08	1.97	1.73***	2.00
Kennebec	2.20	2.21	2.18	2.46	1.96	2.08***	2.18
Norland	2.31	2.24	1.82	2.36	1.77	2.13***	2.10
Pontiac	2.29	2.11	2.58	2.36	2.00	2.25***	2.26
Viking	2.20	2.07	2.33	2.23	1.99	2.30***	2.19
Storage Condition Mean	2.25	2.15	2.30	1.94	1.94	2.10	2.15

* Expressed as mg iron/100 gm dry potato tissue.

** Storage temperature and date of sample preparation.

***Conditioned at 20°C for three weeks.

The results could also suggest that the method itself is not as precise as one may think and therefore all values should be rounded off to the nearest mg.

Significant differences at the 5% level were detected among varieties and among the fertilizer level X storage condition interaction. Because of very small mean square error terms it is unlikely that suitable conclusions could be made to justify agronomically what was observed statistically.

4.6 Potato Chip Color

A study was carried out to determine whether or not useful equations could be calculated for the prediction of potato chip color. A computer program was written in Fortran IV to calculate all possible regression lines with different significant factors using color as the dependent variable and all combinations of chemical compositions as the independent variables.

The program was further designed to calculate all possible multiple and partial correlation coefficients for each of the factors significant in the analysis of variance for sugar, nitrogen and color. Since this volume of data would probably cover several hundred pages, only a summary of the effects of sugar alone and the effects of sugar and nitrogen on chip color have been given in Table VII for all levels of the variety and storage conditions factors as well as all their interactions.

TABLE VII

REGRESSION AND CORRELATION ANALYSIS ON EXPERIMENTAL DATA SHOWING EFFECTS OF REDUCING SUGAR AND AMINO NITROGEN CONTENT UPON POTATO CHIP COLOR

Treatment	Sample Size	Effect of Sugar on Color		Effect of Sugar and Nitrogen on Color		
		r_{cs}	t_s [1]	R_{csn}	t_n [2]	t_s [3]
Main Effects Varieties:						
Netted Gem	72	-.797	-11.048**	.804	-1.423	-10.999**
Kennebec	72	-.711	- 8.452**	.718	1.279	- 8.567**
Norland	72	-.792	-10.869**	.811	2.447*	-11.512**
Pontiac	72	-.576	- 5.895**	.591	-1.385	- 3.068**
Viking	72	-.729	- 8.916**	.751	-2.267*	- 9.152**
Main Effects Storage Conditions:						
10°C Dec.1/69	60	-.334	- 2.702**	.435	2.325*	- 2.430*
4.5°C Feb.1/70	60	-.680	- 7.077**	.682	0.377	- 6.596**
10°C Feb.1/70	60	-.494	- 4.322**	.685	4.919**	- 6.835**
4.5°C Apr.1/70	60	-.652	- 6.554**	.686	-2.210*	- 5.590**
10°C Apr.1/70	60	-.714	- 7.778**	.728	-1.568	- 7.230**
4.5°C Apr.1/70	60	-.532	- 4.782**	.576	-2.049*	- 3.284**
Interactions - Variety X Storage Conditions: Netted Gem at:						
10°C Dec.1/69	12	-.190	- 0.612	.260	0.555	- 0.374
4.5°C Feb.1/70	12	-.781	- 3.961**	.791	0.591	- 3.767**
10°C Feb.1/70	12	-.240	- 0.780	.365	0.888	- 0.511
4.5°C Apr.1/70	12	-.554	- 2.108	.556	0.113	- 1.924
10°C Apr.1/70	12	-.476	- 1.714	.487	-0.353	- 1.599
4.5°C Apr.1/70	12	-.785	- 4.001**	.942	-4.664**	- 1.755

TABLE VII continued

Kennebec at:						
10°C Dec.1/69	12	-.822	- 4.567**	.911	2.842*	- 5.048**
4.5°C Feb.1/70	12	-.044	- 0.140	.602	2.259	- 0.471
10°C Feb.1/70	12	-.426	- 1.491	.576	-1.423	- 0.816
4.5°C Apr.1/70	12	-.548	- 2.075	.616	-1.067	- 2.051
10°C Apr.1/70	12	.290	0.959	.290	-0.021	0.884
4.5°C Apr.1/70	12	-.046	- 0.145	.092	0.243	- 0.161
Norland at:						
10°C Dec.1/69	12	-.218	- .707	.222	-0.133	- 0.673
4.5°C Feb.1/70	12	-.930	- 7.974**	.936	-0.936	- 7.920**
10°C Feb.1/70	12	-.014	- 0.044	.235	0.724	- 0.686
4.5°C Apr.1/70	12	-.618	- 2.490*	.619	-0.094	- 2.279*
10°C Apr.1/70	12	-.533	- 2.000	.583	0.871	- 2.154
4.5°C Apr.1/70	12	-.145	- 0.465	.268	-0.702	0.196
Pontiac at:						
10°C Dec.1/70	12	+.526	1.959	.566	0.753	1.570
4.5°C Feb.1/70	12	-.544	- 2.061	.547	-0.139	- 1.734
10°C Feb.1/70	12	-.069	- 0.221	.320	0.989	0.033
4.5°C Apr.1/70	12	+.230	0.747	.280	-0.500	0.786
10°C Apr.1/70	12	-.422	- 1.471	.552	-1.281	- 1.476
4.5°C Apr.1/70	12	-.394	- 1.355	.669	-2.189	- 1.409
Viking at:						
10°C Dec.1/70	12	-.138	- 0.441	.256	0.670	- 0.476
4.5°C Feb.1/70	12	-.544	- 2.055	.583	-0.764	- 2.098
10°C Feb.1/70	12	-.645	- 2.673*	.708	-1.245	- 2.811*
4.5°C Apr.1/70	12	-.355	- 1.200	.355	-0.061	- 1.124
10°C Apr.1/70	12	-.422	- 1.473	.428	-0.231	- 1.400
4.5°C Apr.1/70	12	-.325	- 1.086	.734	2.909	- 1.340

* Significant at 5% level.
**Significant at 1% level.
1 t test for simple regression coefficient.
2 t test for partial regression coefficient (contribution to multiple regression equation by nitrogen content).
3 t test for partial regression coefficient (contribution to multiple regression equation by sugar content).

From this table one can see that reducing sugar and nitrogen content appear to be good predictors of potato chip color when considering the varieties and storage conditions as main effects. These results would agree with literature reviews which show that potato chip color is primarily due to the Maillard reaction. When the variety X storage condition interactions are used as a means of classification for the calculation of correlation coefficients and regression equations, reducing sugar and nitrogen content produce significant regression equations for only certain levels of the interactions. No single variety produced significant regression lines for all storage conditions. This would tend to emphasize the variability of, and therefore, the uncertainty in dealing with biological materials. It would seem that storage conditions considered for all varieties give satisfactory prediction equations because of varietal differences with respect to sugar content. Similarly, varieties when considered over all storage conditions give satisfactory prediction equations because of differences in reducing sugar accumulation under different storage conditions.

Although there seems to be a definite relationship between reducing sugar content and potato chip color, it would seem that there is too much variability amongst the tubers to allow one to predict potato chip color accurately. The author would like to suggest that further studies be conducted using a greater number of replicates. It seems

TABLE VIII

AVERAGE 'L' VALUE, DETERMINED ON THE "HUNTERLAB" COLOR DIFFERENCE METER, FOR THE CHIPS OBTAINED FROM THE EXPERIMENTAL POTATOES

Variety	Storage Conditions						Variety Mean
	10°C* Dec.1/69	4.5°C* Feb.1/70	10°C* Feb.1/70	4.5°C* Apr.1/70	10°C* Apr.1/70	4.5°C* Apr.1/70	
Netted Gem	36.4	30.0	39.1	33.2	41.7	38.5**	36.3
Kennebec	36.6	28.4	40.0	32.6	42.9	37.8**	36.4
Norland	41.1	26.3	41.6	29.2	41.9	35.7**	36.0
Pontiac	33.7	25.3	34.3	25.8	34.9	29.9**	30.6
Viking	34.6	25.2	35.6	27.2	37.4	32.2**	32.0
Storage Condition MMean	36.5	26.8	38.1	29.6	39.8	34.8	34.3

* Storage temperature and date of sample preparation.

**Conditioned at 20°C for three weeks.

that two replicates are not sufficient to provide a good treatment mean for the data obtained from the tubers sampled in this study.

The analysis of variance (Appendix XIII) reveals differences at the 1% level among varieties, among storage conditions, among the variety X storage condition interactions, and among the location X variety X storage condition interactions. Differences at the 5% level were detected among the location X storage condition interactions.

Although the location X storage conditions interactions and the location X variety X storage conditions interactions are significant, there does not seem to be a rational explanation for these effects in terms of chemical composition.

Unpublished earlier research by the author into the effects of steam and water blanching on potato chip color has shown that in general water blanched potatoes yield chips with a higher L value than steam blanched chips from the same sample of potatoes. The difference between the results was about 8.3 units (Appendix XIV). A higher L value indicates a lighter chip color since a pure white tile has a reference L value of 100 while a black tile has a reference value of 0. A minimum L value of 45 has been suggested by the Morden Experimental Station research team for desirable chip color. Using this arbitrary value and the figures shown in Table VIII, it may be concluded that Kennebec, Netted Gem and Norland varieties can continue to be successfully used for potato chip manufacture.

Potatoes stored at 40°F can sometimes be reconditioned at higher temperatures to give an acceptable chip color. In this study, levels of reducing sugars and amino nitrogen were low for most treatments. It was unfortunate that a better selection of more variable potato tubers was not made. The study tends to confirm that reconditioning can be used to obtain a suitable processing quality potato tuber when the nitrogenous content is low.

The complexity of this project did not allow analysis of the tubers for total sugar or total non-reducing sugar content. For this reason, no conclusions could be reported to agree or disagree with Yamaguchi et al. (28). However, preliminary work carried out by the author tended to indicate that some potatoes do not give an attractive potato chip color even though the reducing sugar content is low.

On the basis of the results obtained from this study, no sound equations for prediction of potato chip color from the content of reducing sugar, amino nitrogen, soluble iron, and total phenols could be obtained. Obviously other factors not studied play a more important role.

V CONCLUSIONS, WITH SUGGESTIONS FOR FURTHER STUDIES

Literature reviews suggest that significant correlation can be obtained between potato chip color and tuber chemical composition. By use of the multiple regression equation $Y = b_0 + b_1X_1 + \cdots + b_n X_n$ the author was unable to derive any satisfactory prediction equations that would satisfy all conditions considered in the study. This study confirmed results obtained by researchers working with similar biological material.

This study can only emphasize the need to grow good processing varieties such as Netted Gem, Kennebec and Norland. Because of the possible implication of reducing sugar content in the determination of potato chip color, the potato processing industry would welcome more varieties that would meet all requirements when processed directly out of storage at lower temperatures. Such research is now being expedited at several potato breeding centres in North America and overseas.

The author recommends a further study of this research project. Some factors which should be considered in undertaking a project of this type would be:

1) use of fewer treatments,

2) use of at least four to six replicates,

3) certain of the chemical components should be given major attention.

No consideration should be given to iron content, unless fields in different parts of the province are considered. Chlorogenic acid content should be done along with total

phenols. A major study should be carried out, including examination of the levels of each type of sugar and the nitrogen compounds that are normally found in the tuber.

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APPENDIX I

PREPARATION OF AMMONIA-FREE WATER

Distilled water was placed into a two-liter round bottom flask. To each liter of distilled water, bromine water (2 ml) was added. The water was redistilled and the first 100 ml were discarded. The remainder was used as soon as possible.

APPENDIX II

CONSTRUCTION OF BOILING WATER BATH

A test tube rack was constructed from sheet metal to hold sixteen one-inch diameter test tubes each eight inches long. The rack was fitted into a deep copper bottomed saucepan. The water level in the vessel was maintained at approximately four inches so that no part of the liquid within the test tube remained above the level of the boiling water. The temperature of the water bath was kept constant by using a "Moffat" electric kitchen range as a source of heat.

APPENDIX III

ANALYSIS OF VARIANCE
AVERAGE FRYING TEMPERATURES FOR POTATO CHIP SAMPLES

ANALYSIS OF VARIANCE

AVERAGE FRYING TEMPERATURES FOR POTATO CHIP SAMPLES

Source	Degrees of Freedom	Sum of Squares (°F)	Sum of Squares (°C)	MS (°F)	MS (°C)	F (°F)	F (°C)
Times	4	2400.0	768.0	600.0	192.0		
Samples	29	544.0	172.0	18.7586	5.9310	8.00*	9.17*
Error	116	272.0	75.0	2.3448	.6466		
Total	149	3216.0	1015.0				

*Significant at the 1% level.

APPENDIX IV

REDUCING SUGAR CONTENT OF EXPERIMENTAL TUBERS (EXPRESSED AS gm GLUCOSE/100 gm DRY POTATO TISSUE)

REDUCING SUGAR CONTENT OF EXPERIMENTAL TUBERS*

Lbs. K_2O per acre	Variety	Replicate	Storage Conditions					
			10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C*** Apr.1/70
Irrigated Plots:								
60.	NETTED GEM	I	1.27	2.56	1.06	1.42	0.45	0.30
60.	NETTED GEM	III	1.33	4.35	0.75	2.69	1.07	1.49
60.	KENNEBEC	I	1.31	7.41	0.27	3.19	0.52	0.34
60.	KENNEBEC	III	1.13	3.81	0.65	2.52	1.67	1.35
60.	NORLAND	I	1.08	6.92	0.40	3.81	0.45	1.29
60.	NORLAND	III	0.75	5.38	0.79	3.00	0.44	2.98
60.	PONTIAC	I	2.92	8.21	2.11	4.51	2.29	1.05
60.	PONTIAC	III	1.87	9.13	1.75	5.28	1.28	1.79
60.	VIKING	I	1.73	4.20	1.47	5.11	0.81	1.91
60.	VIKING	III	3.08	3.15	1.40	2.61	1.23	1.54
120.	NETTED GEM	I	2.22	1.45	0.98	1.45	0.63	2.36
120.	NETTED GEM	III	1.00	2.44	0.79	2.71	1.20	0.59
120.	KENNEBEC	I	1.05	4.47	0.57	2.80	0.30	0.66
120.	KENNEBEC	III	1.12	4.42	1.48	2.85	0.58	2.76
120.	NORLAND	I	0.48	6.31	0.57	5.37	0.31	0.36
120.	NORLAND	III	1.52	8.61	0.37	2.57	0.53	1.64
120.	PONTIAC	I	1.64	5.31	1.10	3.85	2.27	2.22
120.	PONTIAC	III	2.84	6.51	2.04	3.09	1.15	3.16
120.	VIKING	I	3.64	3.01	1.73	4.80	1.32	0.92
120.	VIKING	III	3.18	7.03	2.02	2.84	1.08	2.66
180.	NETTED GEM	I	1.06	1.71	0.44	2.21	0.95	0.44
180.	NETTED GEM	III	2.49	3.75	1.16	3.32	1.55	0.66
180.	KENNEBEC	I	0.64	4.35	0.85	3.43	0.55	2.16
180.	KENNEBEC	III	0.92	2.00	0.73	2.67	0.73	0.92
180.	NORLAND	I	0.81	2.89	0.38	3.67	1.17	1.66
180.	NORLAND	III	1.16	4.53	0.27	2.55	0.99	1.31
180.	PONTIAC	I	2.87	9.07	1.51	5.02	2.56	2.05
180.	PONTIAC	III	1.87	4.26	2.24	6.21	1.79	2.92
180.	VIKING	I	2.98	4.52	1.84	3.12	2.52	1.62
180.	VIKING	III	2.82	5.95	2.15	4.04	1.88	2.37

APPENDIX IV continued

Non-Irrigated Plots:

60.	NETTED GEM	I	1.24	1.84	0.86	1.47	0.64	0.89
60.	NETTED GEM	III	0.90	5.55	1.05	2.32	0.88	1.05
60.	KENNEBEC	I	1.17	2.63	0.30	2.88	0.47	1.11
60.	KENNEBEC	III	0.91	4.11	0.46	2.29	0.63	0.54
60.	NORLAND	I	1.39	3.37	1.29	2.53	1.94	1.33
60.	NORLAND	III	0.99	1.72	4.13	1.79	0.25	1.70
60.	PONTIAC	I	2.61	10.74	1.51	7.68	3.17	2.15
60.	PONTIAC	III	3.04	1.17	2.00	2.26	2.48	1.66
60.	VIKING	I	3.56	4.15	1.58	4.22	1.07	2.33
60.	VIKING	III	2.90	7.27	0.98	2.71	1.37	2.68
120.	NETTED GEM	I	1.17	3.09	0.61	1.57	0.47	0.31
120.	NETTED GEM	III	1.04	1.90	1.02	1.52	0.59	0.33
120.	KENNEBEC	I	1.15	3.90	0.69	1.05	0.33	0.46
120.	KENNEBEC	III	1.04	2.95	1.63	3.59	0.60	0.30
120.	NORLAND	I	1.40	2.20	0.92	4.83	0.52	0.59
120.	NORLAND	III	0.53	5.40	0.16	3.43	0.39	1.58
120.	PONTIAC	I	2.96	7.96	1.71	2.84	2.01	2.78
120.	PONTIAC	III	4.12	8.08	2.42	4.81	1.92	2.50
120.	VIKING	I	3.79	6.34	1.07	3.00	1.49	0.61
120.	VIKING	III	2.87	2.97	1.30	3.26	1.95	2.33
180.	NETTED GEM	I	0.71	6.12	0.45	1.28	0.53	1.32
180.	NETTED GEM	III	1.20	2.62	1.13	3.23	0.58	0.89
180.	KENNEBEC	I	0.97	3.43	0.48	1.82	0.65	2.15
180.	KENNEBEC	III	1.05	1.74	0.54	1.18	0.50	1.89
180.	NORLAND	I	1.21	1.68	1.27	2.47	1.09	2.65
180.	NORLAND	III	1.10	6.10	0.48	3.47	0.84	1.61
180.	PONTIAC	I	2.52	4.90	1.27	3.91	2.16	2.09
180.	PONTIAC	III	3.11	11.07	1.93	5.00	1.83	3.70
180.	VIKING	I	2.44	4.24	0.87	3.72	1.40	1.38
180.	VIKING	III	2.31	6.60	1.97	4.36	1.77	2.23

*Expressed as gm gm glucose/100 gm dry potato tissue.

**Storage temperature and date of sample preparation.

***Storage temperature and date of sample preparation. Sample conditioned at 20°C for 3 weeks.

APPENDIX V

AQUEOUS ALCOHOL-SOLUBLE NITROGEN CONTENT OF EXPERIMENTAL TUBERS (EXPRESSED AS gm NITROGEN/100 gm DRY POTATO TISSUE)

AQUEOUS ALCOHOL-SOLUBLE NITROGENOUS CONTENT OF EXPERIMENTAL TUBERS*

Lbs. K_2O per acre	Variety	Replicate	Storage Conditions					
			10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C** Apr.1/70
Irrigated Plots:								
60.	NETTED GEM	I	0.57	0.87	0.71	0.76	0.55	0.54
60.	NETTED GEM	III	0.84	0.80	0.71	0.54	0.48	0.60
60.	KENNEBEC	I	0.50	0.71	0.46	0.56	0.46	0.55
60.	KENNEBEC	III	0.52	0.56	0.52	0.73	0.55	0.84
60.	NORLAND	I	0.74	0.62	0.56	0.69	0.50	0.76
60.	NORLAND	III	0.78	0.99	0.94	0.75	0.44	0.86
60.	PONTIAC	I	0.73	0.74	0.42	1.05	0.63	0.76
60.	PONTIAC	III	0.55	0.72	0.58	0.66	0.49	0.88
60.	VIKING	I	0.53	0.80	0.57	0.86	0.60	0.89
60.	VIKING	III	0.53	0.71	0.47	0.81	0.75	0.80
120.	NETTED GEM	I	0.62	0.83	0.58	0.74	0.49	0.68
120.	NETTED GEM	III	0.88	0.44	0.62	0.52	0.37	0.58
120.	KENNEBEC	I	0.54	0.76	0.61	0.60	0.42	0.87
120.	KENNEBEC	III	0.57	0.47	0.86	0.84	0.65	0.63
120.	NORLAND	I	0.79	0.87	0.43	0.77	0.46	0.67
120.	NORLAND	III	0.59	0.73	0.54	0.94	0.45	0.78
120.	PONTIAC	I	0.52	0.80	0.65	0.76	0.54	0.95
120.	PONTIAC	III	0.76	0.75	0.64	1.12	0.52	1.05
120.	VIKING	I	0.46	0.48	0.43	0.70	0.83	0.94
120.	VIKING	III	0.51	0.84	0.39	0.87	0.78	0.92
180.	NETTED GEM	I	0.80	0.50	0.85	0.73	0.43	0.55
180.	NETTED GEM	III	0.52	0.54	0.44	0.81	0.62	0.49
180.	KENNEBEC	I	0.66	0.72	0.66	0.59	0.62	0.70
180.	KENNEBEC	III	0.54	0.45	0.47	0.45	0.57	0.60
180.	NORLAND	I	0.88	0.82	0.84	0.79	0.53	0.90
180.	NORLAND	III	0.84	0.53	0.66	0.69	0.49	0.77
180.	PONTIAC	I	0.51	0.68	0.37	0.63	0.53	1.15
180.	PONTIAC	III	0.72	0.62	0.61	0.74	0.65	0.81
180.	VIKING	I	0.66	0.98	0.50	0.74	0.54	1.01
180.	VIKING	III	0.65	0.72	0.44	0.81	0.54	0.89

APPENDIX V continued

Non-Irrigated Plots:

60.	NETTED GEM	I	0.46	0.52	0.46	0.72	0.51	0.67
60.	NETTED GEM	III	0.82	0.48	0.80	0.65	0.60	0.62
60.	KENNEBEC	I	0.56	0.57	0.84	0.68	0.67	0.68
60.	KENNEBEC	III	0.49	0.69	0.52	0.58	0.46	0.66
60.	NORLAND	I	0.63	0.86	0.65	0.79	0.66	0.60
60.	NORLAND	III	0.70	0.64	4.36	0.49	0.46	0.73
60.	PONTIAC	I	0.64	0.50	0.94	1.03	0.58	0.94
60.	PONTIAC	III	0.89	0.58	0.47	0.83	0.64	0.63
60.	VIKING	I	0.51	0.55	0.72	0.89	0.74	0.86
60.	VIKING	III	0.80	0.49	0.39	0.83	0.83	0.98
120.	NETTED GEM	I	0.82	0.52	0.40	0.77	0.43	0.21
120.	NETTED GEM	III	1.01	0.46	0.75	0.65	0.45	0.70
120.	KENNEBEC	I	0.70	0.59	0.58	0.65	0.91	0.37
120.	KENNEBEC	III	0.47	0.84	0.73	0.81	0.75	0.72
120.	NORLAND	I	0.67	0.69	0.46	0.80	0.64	0.60
120.	NORLAND	III	0.62	0.48	0.81	0.88	0.66	0.72
120.	PONTIAC	I	0.52	0.78	0.85	0.52	0.89	0.71
120.	PONTIAC	III	0.73	0.77	0.49	0.76	0.81	0.79
120.	VIKING	I	0.87	0.58	0.63	0.65	0.47	0.68
120.	VIKING	III	0.56	0.77	0.57	0.77	0.80	0.84
180.	NETTED GEM	I	0.53	0.57	0.68	0.69	0.52	0.31
180.	NETTED GEM	III	0.45	0.65	0.43	0.69	0.56	0.62
180.	KENNEBEC	I	0.83	0.43	0.75	0.72	0.67	0.84
180.	KENNEBEC	III	0.62	0.78	0.61	0.66	0.88	0.88
180.	NORLAND	I	0.57	0.67	0.65	0.85	0.45	0.40
180.	NORLAND	III	0.89	0.61	0.53	1.01	0.53	0.72
180.	PONTIAC	I	0.48	0.53	0.51	0.75	0.75	0.78
180.	PONTIAC	III	0.54	1.02	0.53	0.90	0.79	0.72
180.	VIKING	I	0.63	0.49	0.46	0.90	0.85	0.84
180.	VIKING	III	0.68	0.44	0.63	0.81	0.72	0.98

*Expressed as gm nitrogen/100 gm dry potato tissue.

**Storage temperature and date of sample preparation.

***Storage temperature and date of sample preparation. Sample conditioned at 20°C for 3 weeks.

APPENDIX VI

TOTAL PHENOLS CONTENT OF EXPERIMENTAL TUBERS (EXPRESSED AS gm CATECHOL/100 gm DRY POTATO TISSUE)

TOTAL PHENOLS CONTENT OF EXPERIMENTAL TUBERS*

Lbs. K_2O per acre	Variety	Replicate	Storage Conditions					
			10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C*** Apr.1/70
Irrigated Plots:								
60.	NETTED GEM	I	0.11	0.14	0.11	0.13	0.15	0.15
60.	NETTED GEM	III	0.14	0.10	0.12	0.13	0.11	0.09
60.	KENNEBEC	I	0.09	0.10	0.11	0.11	0.13	0.13
60.	KENNEBEC	III	0.11	0.13	0.10	0.10	0.18	0.17
60.	NORLAND	I	0.11	0.11	0.11	0.08	0.14	0.14
60.	NORLAND	III	0.11	0.17	0.13	0.12	0.11	0.10
60.	PONTIAC	I	0.11	0.11	0.10	0.10	0.18	0.13
60.	PONTIAC	III	0.10	0.12	0.11	0.14	0.13	0.13
60.	VIKING	I	0.10	0.07	0.13	0.14	0.07	0.13
60.	VIKING	III	0.11	0.11	0.12	0.15	0.12	0.11
120.	NETTED GEM	I	0.14	0.11	0.14	0.10	0.16	0.10
120.	NETTED GEM	III	0.13	0.11	0.14	0.11	0.12	0.10
120.	KENNEBEC	I	0.09	0.13	0.15	0.10	0.19	0.15
120.	KENNEBEC	III	0.10	0.08	0.10	0.13	0.13	0.08
120.	NORLAND	I	0.08	0.11	0.11	0.13	0.14	0.10
120.	NORLAND	III	0.11	0.10	0.12	0.11	0.12	0.13
120.	PONTIAC	I	0.12	0.06	0.09	0.10	0.12	0.13
120.	PONTIAC	III	0.10	0.10	0.09	0.13	0.12	0.12
120.	VIKING	I	0.07	0.08	0.08	0.14	0.22	0.14
120.	VIKING	III	0.14	0.13	0.12	0.09	0.11	0.07
180.	NETTED GEM	I	0.14	0.14	0.12	0.10	0.12	0.09
180.	NETTED GEM	III	0.15	0.15	0.12	0.10	0.14	0.11
180.	KENNEBEC	I	0.10	0.10	0.11	0.08	0.15	0.12
180.	KENNEBEC	III	0.11	0.10	0.09	0.08	0.11	0.07
180.	NORLAND	I	0.13	0.14	0.10	0.07	0.18	0.11
180.	NORLAND	III	0.10	0.13	0.12	0.11	0.13	0.11
180.	PONTIAC	I	0.09	0.14	0.10	0.05	0.13	0.14
180.	PONTIAC	III	0.11	0.11	0.11	0.13	0.09	0.11
180.	VIKING	I	0.12	0.10	0.09	0.15	0.01	0.07
180.	VIKING	III	0.11	0.10	0.12	0.10	0.06	0.11

APPENDIX VI continued

Non-Irrigated Plots:

60.	NETTED GEM	I	0.14	0.08	0.09	0.10	0.11	0.08
60.	NETTED GEM	III	0.12	0.10	0.10	0.14	0.06	0.09
60.	KENNEBEC	I	0.10	0.09	0.11	0.09	0.11	0.09
60.	KENNEBEC	III	0.08	0.10	0.09	0.10	0.09	0.10
60.	NORLAND	I	0.10	0.12	0.12	0.12	0.07	0.09
60.	NORLAND	III	0.09	0.12	0.97	0.09	0.11	0.09
60.	PONTIAC	I	0.13	0.12	0.12	0.12	0.12	0.10
60.	PONTIAC	III	0.11	0.07	0.09	0.14	0.12	0.07
60.	VIKING	I	0.15	0.08	0.11	0.09	0.11	0.09
60.	VIKING	III	0.10	0.11	0.08	0.09	0.11	0.10
120.	NETTED GEM	I	0.13	0.10	0.12	0.12	0.11	0.12
120.	NETTED GEM	III	0.09	0.08	0.11	0.13	0.09	0.09
120.	KENNEBEC	I	0.08	0.10	0.09	0.11	0.13	0.10
120.	KENNEBEC	III	0.06	0.10	0.10	0.10	0.09	0.12
120.	NORLAND	I	0.09	0.13	0.09	0.11	0.12	0.07
120.	NORLAND	III	0.09	0.09	0.10	0.12	0.10	0.10
120.	PONTIAC	I	0.10	0.10	0.10	0.08	0.08	0.11
120.	PONTIAC	III	0.08	0.08	0.16	0.13	0.11	0.12
120.	VIKING	I	0.11	0.12	0.09	0.09	0.08	0.13
120.	VIKING	III	0.10	0.12	0.09	0.09	0.10	0.14
180.	NETTED GEM	I	0.11	0.09	0.11	0.12	0.15	0.10
180.	NETTED GEM	III	0.12	0.13	0.11	0.10	0.08	0.13
180.	KENNEBEC	I	0.09	0.11	0.10	0.11	0.13	0.13
180.	KENNEBEC	III	0.13	0.13	0.10	0.11	0.13	0.08
180.	NORLAND	I	0.10	0.16	0.13	0.20	0.14	0.08
180.	NORLAND	III	0.10	0.13	0.11	0.12	0.12	0.10
180.	PONTIAC	I	0.07	0.13	0.14	0.09	0.11	0.08
180.	PONTIAC	III	0.06	0.13	0.08	0.13	0.11	0.08
180.	VIKING	I	0.08	0.14	0.09	0.11	0.09	0.12
180.	VIKING	III	0.09	0.08	0.07	0.11	0.11	0.08

*Expressed as gm catechol/100 gm dry potato tissue.

**Storage temperature and date of sample preparation.

***Storage temperature and date of sample preparation. Sample conditioned at 20°C for 3 weeks.

APPENDIX VII

TOTAL SOLUBLE IRON CONTENT OF EXPERIMENTAL TUBERS (EXPRESSED AS gm IRON/100 gm DRY POTATO TISSUE)

TOTAL SOLUBLE IRON CONTENT OF EXPERIMENTAL TUBERS*

Lbs. K_2O per acre	Variety	Replicate	Storage Conditions					
			10°C** Dec.1/69	4.5°C** Feb.1/70	10°C** Feb.1/70	4.5°C** Apr.1/70	10°C** Apr.1/70	4.5°C*** Apr.1/70
Irrigated Plots:								
60.	NETTED GEM	I	0.0021	0.0017	0.0022	0.0019	0.0021	0.0016
60.	NETTED GEM	III	0.0017	0.0017	0.0015	0.0021	0.0018	0.0021
60.	KENNEBEC	I	0.0023	0.0015	0.0031	0.0026	0.0028	0.0016
60.	KENNEBEC	III	0.0018	0.0019	0.0022	0.0024	0.0018	0.0023
60.	NORLAND	I	0.0021	0.0017	0.0018	0.0023	0.0022	0.0023
60.	NORLAND	III	0.0027	0.0024	0.0015	0.0021	0.0018	0.0019
60.	PONTIAC	I	0.0026	0.0013	0.0019	0.0030	0.0020	0.0018
60.	PONTIAC	III	0.0021	0.0019	0.0024	0.0017	0.0019	0.0020
60.	VIKING	I	0.0023	0.0022	0.0019	0.0019	0.0015	0.0017
60.	VIKING	III	0.0020	0.0025	0.0022	0.0025	0.0018	0.0020
120.	NETTED GEM	I	0.0024	0.0023	0.0023	0.0019	0.0023	0.0016
120.	NETTED GEM	III	0.0021	0.0014	0.0018	0.0026	0.0024	0.0014
120.	KENNEBEC	I	0.0025	0.0018	0.0026	0.0039	0.0022	0.0018
120.	KENNEBEC	III	0.0015	0.0016	0.0017	0.0022	0.0017	0.0015
120.	NORLAND	I	0.0018	0.0015	0.0021	0.0031	0.0028	0.0022
120.	NORLAND	III	0.0027	0.0016	0.0017	0.0021	0.0016	0.0018
120.	PONTIAC	I	0.0022	0.0018	0.0017	0.0023	0.0028	0.0024
120.	PONTIAC	III	0.0022	0.0014	0.0020	0.0024	0.0018	0.0020
120.	VIKING	I	0.0023	0.0018	0.0055	0.0023	0.0021	0.0017
120.	VIKING	III	0.0020	0.0017	0.0021	0.0028	0.0015	0.0023
180.	NETTED GEM	I	0.0029	0.0019	0.0016	0.0019	0.0023	0.0016
180.	NETTED GEM	III	0.0022	0.0031	0.0025	0.0023	0.0024	0.0026
180.	KENNEBEC	I	0.0021	0.0019	0.0019	0.0024	0.0020	0.0021
180.	KENNEBEC	III	0.0016	0.0024	0.0015	0.0029	0.0022	0.0022
180.	NORLAND	I	0.0023	0.0022	0.0017	0.0019	0.0022	0.0023
180.	NORLAND	III	0.0018	0.0032	0.0018	0.0025	0.0014	0.0030
180.	PONTIAC	I	0.0019	0.0025	0.0038	0.0021	0.0023	0.0023
180.	PONTIAC	III	0.0023	0.0028	0.0024	0.0020	0.0013	0.0030
180.	VIKING	I	0.0017	0.0018	0.0014	0.0025	0.0020	0.0020
180.	VIKING	III	0.0020	0.0023	0.0027	0.0021	0.0017	0.0026

APPENDIX VII continued

Non-Irrigated Plots:

60.	NETTED GEM	I	0.0026	0.0013	0.0026	0.0016	0.0015	0.0014
60.	NETTED GEM	III	0.0022	0.0031	0.0015	0.0020	0.0018	0.0017
60.	KENNEBEC	I	0.0022	0.0017	0.0016	0.0022	0.0017	0.0021
60.	KENNEBEC	III	0.0021	0.0027	0.0033	0.0022	0.0018	0.0020
60.	NORLAND	I	0.0022	0.0021	0.0022	0.0023	0.0018	0.0023
60.	NORLAND	III	0.0032	0.0025	0.0017	0.0022	0.0015	0.0017
60.	PONTIAC	I	0.0024	0.0017	0.0020	0.0040	0.0020	0.0024
60.	PONTIAC	III	0.0028	0.0023	0.0023	0.0021	0.0016	0.0018
60.	VIKING	I	0.0022	0.0021	0.0022	0.0020	0.0015	0.0040
60.	VIKING	III	0.0028	0.0017	0.0015	0.0023	0.0030	0.0020
120.	NETTED GEM	I	0.0021	0.0022	0.0021	0.0023	0.0012	0.0015
120.	NETTED GEM	III	0.0036	0.0018	0.0011	0.0020	0.0022	0.0020
120.	KENNEBEC	I	0.0024	0.0018	0.0022	0.0025	0.0016	0.0017
120.	KENNEBEC	III	0.0027	0.0025	0.0020	0.0021	0.0020	0.0024
120.	NORLAND	I	0.0024	0.0021	0.0016	0.0023	0.0014	0.0018
120.	NORLAND	III	0.0023	0.0023	0.0015	0.0027	0.0016	0.0019
120.	PONTIAC	I	0.0028	0.0017	0.0027	0.0022	0.0027	0.0023
120.	PONTIAC	III	0.0024	0.0020	0.0022	0.0023	0.0022	0.0026
120.	VIKING	I	0.0023	0.0031	0.0020	0.0017	0.0023	0.0029
120.	VIKING	III	0.0023	0.0019	0.0023	0.0023	0.0021	0.0022
180.	NETTED GEM	I	0.0003	0.0017	0.0018	0.0022	0.0018	0.0016
180.	NETTED GEM	III	0.0025	0.0032	0.0013	0.0021	0.0019	0.0015
180.	KENNEBEC	I	0.0033	0.0037	0.0019	0.0022	0.0018	0.0024
180.	KENNEBEC	III	0.0018	0.0030	0.0020	0.0019	0.0020	0.0028
180.	NORLAND	I	0.0025	0.0026	0.0021	0.0019	0.0014	0.0019
180.	NORLAND	III	0.0017	0.0028	0.0021	0.0028	0.0016	0.0024
180.	PONTIAC	I	0.0018	0.0030	0.0059	0.0019	0.0015	0.0018
180.	PONTIAC	III	0.0020	0.0029	0.0015	0.0024	0.0020	0.0025
180.	VIKING	I	0.0024	0.0018	0.0017	0.0024	0.0023	0.0024
180.	VIKING	III	0.0022	0.0018	0.0024	0.0020	0.0021	0.0018

*Expressed as gm iron/100 gm dry potato tissue.

**Storage temperature and date of sample preparation.

***Storage temperature and date of sample preparation. Sample conditioned at 20°C for 3 weeks.

APPENDIX VIII

L VALUES DETERMINED ON THE "HUNTERLAB" COLOR DIFFERENCE METER FOR THE POTATO CHIPS OBTAINED FROM THE EXPERIMENTAL TUBERS

L VALUES DETERMINED ON THE "HUNTERLAB" COLOR DIFFERENCE METER FOR THE POTATO CHIPS OBTAINED FROM THE EXPERIMENTAL TUBERS

Lbs. K_2O per acre	Variety	Replicate	Storage Conditions					
			10°C* Dec.1/69	4.5°C* Feb.1/70	10°C* Feb.1/70	4.5°C* Apr.1/70	10°C* Apr.1/70	4.5°C** Apr.1/70
Irrigated Plots:								
60.	NETTED GEM	I	36.0	31.7	36.3	34.2	40.4	39.2
60.	NETTED GEM	III	36.7	28.5	43.9	32.5	43.3	34.5
60.	KENNEBEC	I	34.5	29.9	38.5	30.7	47.2	42.3
60.	KENNEBEC	III	34.9	25.1	38.0	31.1	46.8	36.3
60.	NORLAND	I	36.3	24.4	39.5	29.6	41.0	35.4
60.	NORLAND	III	35.8	23.7	40.9	27.3	40.8	32.3
60.	PONTIAC	I	31.9	25.6	34.0	27.4	27.8	31.4
60.	PONTIAC	III	30.1	23.4	31.8	26.8	39.0	30.1
60.	VIKING	I	32.4	25.8	33.5	25.7	37.3	35.5
60.	VIKING	III	32.7	24.7	38.5	28.4	37.4	31.9
120.	NETTED GEM	I	37.6	29.1	37.9	33.2	42.1	34.6
120.	NETTED GEM	III	34.2	28.3	43.4	30.5	40.4	37.0
120.	KENNEBEC	I	34.0	30.6	40.3	33.9	41.5	39.8
120.	KENNEBEC	III	33.8	26.8	36.3	31.3	37.3	36.9
120.	NORLAND	I	38.4	24.7	38.9	28.3	42.0	32.6
120.	NORLAND	III	35.2	22.2	41.9	31.2	41.8	35.3
120.	PONTIAC	I	30.9	25.5	33.5	24.8	36.7	34.3
120.	PONTIAC	III	27.0	22.6	33.0	24.4	39.6	28.7
120.	VIKING	I	35.6	26.2	33.6	27.8	35.4	35.2
120.	VIKING	III	33.9	24.9	37.9	28.0	35.2	31.5
180.	NETTED GEM	I	40.5	34.2	37.8	37.5	41.0	38.7
180.	NETTED GEM	III	34.7	27.7	35.6	29.7	36.8	39.6
180.	KENNEBEC	I	45.1	29.3	38.3	33.2	43.7	42.3
180.	KENNEBEC	III	37.5	28.0	44.6	30.9	39.2	30.5
180.	NORLAND	I	41.9	28.0	39.0	29.7	42.2	36.8
180.	NORLAND	III	36.4	24.5	45.3	30.7	40.7	31.0
180.	PONTIAC	I	28.0	23.6	31.5	26.9	33.9	30.8
180.	PONTIAC	III	31.3	24.3	34.9	31.2	34.2	28.8
180.	VIKING	I	36.6	24.6	32.1	23.9	30.0	32.6
180.	VIKING	III	29.5	24.5	33.0	26.8	42.3	33.3

APPENDIX VIII continued

Non-Irrigated Plots:

60.	NETTED GEM	I	37.3	30.3	39.3	32.1	43.0	37.6
60.	NETTED GEM	III	37.1	23.4	40.8	34.3	45.1	38.8
60.	KENNEBEC	I	33.3	30.6	37.9	33.3	44.3	35.5
60.	KENNEBEC	III	36.3	26.1	42.0	35.8	42.1	41.8
60.	NORLAND	I	41.9	26.6	43.0	32.8	39.5	39.6
60.	NORLAND	III	49.8	31.1	42.1	31.0	45.7	36.6
60.	PONTIAC	I	30.9	25.1	35.6	23.3	33.2	28.2
60.	PONTIAC	III	45.6	31.6	37.6	26.4	38.2	23.0
60.	VIKING	I	30.6	26.2	33.2	26.7	39.7	30.4
60.	VIKING	III	38.4	24.7	38.3	29.6	43.5	30.4
120.	NETTED GEM	I	36.3	28.5	36.1	34.2	42.1	41.2
120.	NETTED GEM	III	36.7	30.4	38.3	34.8	42.0	43.9
120.	KENNEBEC	I	37.2	28.1	45.1	35.5	45.0	34.3
120.	KENNEBEC	III	35.3	29.2	36.3	29.4	41.4	34.7
120.	NORLAND	I	42.3	29.8	45.4	24.6	45.4	40.5
120.	NORLAND	III	48.6	26.0	49.0	26.9	41.3	34.5
120.	PONTIAC	I	34.6	29.3	36.0	23.3	34.5	31.9
120.	PONTIAC	III	39.9	24.4	32.3	25.4	32.4	30.5
120.	VIKING	I	33.3	23.7	39.5	27.3	39.6	32.0
120.	VIKING	III	39.5	25.5	36.5	29.4	35.4	30.0
180.	NETTED GEM	I	39.1	26.2	40.7	34.1	43.3	41.1
180.	NETTED GEM	III	31.0	29.2	38.9	31.6	40.3	35.5
180.	KENNEBEC	I	40.0	26.2	41.0	31.0	44.6	39.7
180.	KENNEBEC	III	37.6	31.0	41.5	34.1	41.4	38.9
180.	NORLAND	I	38.6	30.3	38.5	28.5	39.8	35.6
180.	NORLAND	III	48.2	23.7	34.9	29.4	42.6	38.5
180.	PONTIAC	I	33.3	24.9	36.0	24.8	36.6	34.4
180.	PONTIAC	III	40.7	23.3	35.0	25.1	32.7	27.0
180.	VIKING	I	32.3	28.2	37.6	25.7	39.3	30.6
180.	VIKING	III	40.8	23.1	33.6	27.2	34.0	32.6

*Storage temperature and date of sample preparation.

**Storage temperature and date of sample preparation. Sample conditioned at 20°C for 3 weeks.

APPENDIX IX

ANALYSIS OF VARIANCE
REDUCING SUGAR CONTENT OF POTATO TUBERS

ANALYSIS OF VARIANCE

REDUCING SUGAR CONTENT OF POTATO TUBERS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Tabulated F(.05)*	Tabulated F(.01)**
Whole Plots						
Blocks	1	1.2488	1.2488		161.4	4052.0
Locations (L)	1	1.0991	1.0991	38.810	161.4	4052.0
Whole Plot Error		0.0283	0.0283			
Split Plots						
Fertilizers (F)	2	0.4980	0.2490	0.155	6.94	18.0
L x F	2	0.2568	0.1284	0.080	6.94	18.0
Split Plot Error	4	6.4324	1.6081			
Split-Split Plots						
Varieties (V)	4	188.6233	47.1558	29.087**	2.78	4.22
L x V	4	4.5693	1.1423	0.705	2.78	4.22
F x V	8	4.0505	0.5063	0.312	2.36	3.36
L x F x V	8	7.5134	0.9392	0.579	2.36	3.36
Split-Split Plot Error	24	38.9087	1.6212	1.6212		
Split-Split-Split Plots						
Storage Conditions (C)	5	606.8931	121.3786	99.428**	2.21	3.02
L x C	5	3.9565	0.7913	0.648	2.21	3.02
F x C	10	4.2695	0.4270	0.350	1.83	2.32
L x F x C	10	12.4497	1.2450	1.020	1.83	2.32
V x C	20	58.5376	2.9269	2.398**	1.57	1.88
L x V x C	20	25.7080	1.2854	1.053	1.57	1.88
F x V x C	40	35.2720	0.8818	0.722	1.39	1.59
L x F x V x C	40	24.6145	0.6154	0.504	1.39	1.59
Split-Split-Split Plot Error	150	183.1150	1.2208			
Total	359	1208.0474				

* 5% level of significance.
** 1% level of significance.

APPENDIX X

ANALYSIS OF VARIANCE
AQUEOUS ALCOHOL-SOLUBLE NITROGENOUS COMPOUNDS
CONTENT OF POTATO TUBERS

ANALYSIS OF VARIANCE

AQUEOUS ALCOHOL-SOLUBLE NITROGENOUS COMPOUNDS CONTENT OF POTATO TUBERS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Tabulated F(.05)*	Tabulated F(.01)**
Whole Plots						
Blocks	1	0.1010	0.1010		161.4	4052.0
Locations (L)	1	0.0363	0.0363	0.247	161.4	4052.0
Whole Plot Error	1	0.1473	0.1473			
Split Plots						
Fertilizers (F)	2	0.0747	0.0373	1.426	6.94	18.0
L x F	2	0.0649	0.0324	1.238	6.94	18.0
Split Plot Error	4	0.1048	0.0262			
Split-Split Plots						
Varieties (V)	4	0.7765	0.1941	4.188*	2.78	4.22
L x V	4	0.1351	0.0338	0.729	2.78	4.22
F x V	8	0.4844	0.0605	1.306	2.36	3.36
L x F x V	8	0.3319	0.0415	0.895	2.36	3.36
Split-Split Plot Error	24	1.1124	0.0463			
Split-Split-Split Plots						
Storage Conditions (C)	5	0.9398	0.1880	3.223**	2.21	3.02
L x C	5	0.7187	0.1437	2.465*	2.21	3.02
F x C	10	0.5813	0.0581	0.997	1.83	2.32
L x F x C	10	0.7080	0.0708	1.214	1.83	2.32
V x C	20	2.3528	0.1176	2.017**	1.57	1.88
L x V x C	20	0.9179	0.0459	0.787	1.57	1.88
F x V x C	40	2.4574	0.0614	1.054	1.39	1.59
L x F x V x C	40	2.0293	0.0507	0.870	1.39	1.59
Split-Split-Split Plot Error	150	8.7471	0.0583			
Total	359	22.8216				

* 5% level of significance.
** 1% level of significance.

APPENDIX XI

ANALYSIS OF VARIANCE
TOTAL PHENOL CONTENT OF POTATO TUBERS

ANALYSIS OF VARIANCE

TOTAL PHENOL CONTENT OF POTATO TUBERS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Tabulated F(.05)*	Tabulated F(.01)**
Whole Plots						
Blocks	1	0.0006	0.0006		161.4	4052.0
Locations (L)	1	0.0023	0.0023	3.615	161.4	4052.0
Whole Plot Error	1	0.0006	0.0006			
Split Plots						
Fertilizers (F)	2	0.0063	0.0031	1.425	6.94	18.0
L x F	2	0.0021	0.0010	0.469	6.94	18.0
Split Plot Error	4	0.0088	0.0022			
Split-Split Plots						
Varieties (V)	4	0.0190	0.0047	1.790	2.78	4.22
L x V	4	0.0100	0.0025	0.938	2.78	4.22
F x V	8	0.0178	0.0022	0.839	2.36	3.36
L x F x V	8	0.0190	0.0024	0.894	2.36	3.36
Split-Split Plot Error	24	0.0637	0.0027			
Split-Split-Split Plots						
Storage Conditions (C)	5	0.0122	0.0024	0.967	2.21	3.02
L x C	5	0.0176	0.0035	1.395	2.21	3.02
F x C	10	0.0249	0.0025	0.987	1.83	2.32
L x F x C	10	0.0346	0.0035	1.372	1.83	2.32
V x C	20	0.0584	0.0029	1.157	1.57	1.88
L x V x C	20	0.0553	0.0028	1.096	1.57	1.88
F x V x C	40	0.1174	0.0029	1.163	1.39	1.59
L x F x V x C	40	0.1002	0.0025	0.993	1.39	1.59
Split-Split-Split Plot Error	150	0.3784	0.0025			
Total	359	0.9492				

* 5% level of significance.
** 1% level of significance.

APPENDIX XII

ANALYSIS OF VARIANCE
SOLUBLE IRON CONTENT OF POTATO TUBERS

ANALYSIS OF VARIANCE

SOLUBLE IRON CONTENT OF POTATO TUBERS

Source	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Tabulated F(.05)*	Tabulated F(.01)**
Whole Plots						
Blocks	1	1.5×10^{-7}	1.5×10^{-7}		161.4	4052.0
Locations (L)	1	1.6×10^{-7}	1.6×10^{-7}	0.450	161.4	4052.0
Whole Plot Error	1	3.7×10^{-7}	3.7×10^{-7}			
Split Plots						
Fertilizers (F)	2	6.5×10^{-7}	3.3×10^{-7}	0.498	6.94	18.0
L x F	2	2.8×10^{-7}	1.4×10^{-7}	0.215	6.94	18.0
Split Plot Error	4	2.6×10^{-6}	6.5×10^{-7}			
Split-Split Plots						
Varieties (V)	4	2.9×10^{-6}	7.3×10^{-7}	3.484*	2.78	4.22
L x V	4	9.0×10^{-7}	2.3×10^{-7}	1.077	2.78	4.22
F x V	8	1.7×10^{-6}	2.1×10^{-7}	1.001	2.36	3.36
L x F x V	8	1.5×10^{-6}	1.9×10^{-7}	0.888	2.36	3.36
Split-Split Plot Error	24	5.0×10^{-6}	2.1×10^{-7}			
Split-Split-Split Plots						
Storage Conditions (C)	5	4.9×10^{-6}	9.7×10^{-7}	3.025**	2.21	3.02
L x C	5	2.7×10^{-6}	5.4×10^{-7}	1.679	2.21	3.02
F x C	10	6.0×10^{-6}	6.0×10^{-7}	1.872*	1.83	2.32
L x F x C	10	2.1×10^{-6}	2.1×10^{-7}	0.663	1.83	2.32
V x C	20	6.2×10^{-6}	3.1×10^{-7}	0.973	1.57	1.88
L x V x C	20	6.2×10^{-6}	3.1×10^{-7}	0.968	1.57	1.88
F x V x C	40	1.3×10^{-5}	3.2×10^{-7}	1.002	1.39	1.59
L x F x V x C	40	5.4×10^{-6}	1.3×10^{-7}	0.417	1.39	1.59
Split-Split-Split Plot Error	150	4.8×10^{-5}	3.2×10^{-7}			
Total	359	1.1×10^{-4}				

* 5% level of significance.
** 1% level of significance.

APPENDIX XIII

ANALYSIS OF VARIANCE
POTATO CHIP COLOR

ANALYSIS OF VARIANCE

POTATO CHIP COLOR

Source	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F	Tabulated F(.05)*	Tabulated F(.01)**
Whole Plots						
Blocks	1	17.6250	17.6250		161.4	4052.0
Locations (L)	1	131.8750	131.8750	4.596	161.4	4052.0
Whole Plot Error	1	28.6875	28.6875			
Split Plots						
Fertilizers (F)	2	29.1250	14.5625	0.790	6.94	18.0
L x F	2	2.5625	1.2813	0.069	6.94	18.0
Split Plot Error	4	73.7500	18.4375			
Split-Split Plots						
Varieties (V)	4	2143.1875	535.7969	58.120**	2.78	4.22
L x V	4	49.5625	12.3906	1.344	2.78	4.22
F x V	8	18.5000	2.3125	0.251	2.36	3.36
L x F x V	8	67.8125	8.4766	0.919	2.36	3.36
Split-Split Plot Error	24	221.2500	9.2188			
Split-Split-Split Plots						
Storage Conditions (C)	5	7667.1250	1533.4248	183.004**	2.21	3.02
L x C	5	97.2500	19.4500	2.321*	2.21	3.02
F x C	10	39.0000	3.9000	0.465	1.83	2.32
L x F x C	10	46.3125	4.6312	0.553	1.83	2.32
V x C	20	556.5625	27.8281	3.321**	1.57	1.88
L x V x C	20	317.3750	15.8687	1.894**	1.57	1.88
F x V x C	40	245.6250	6.1406	0.733	1.39	1.59
L x F x V x C	40	258.8125	6.4703	0.772	1.39	1.59
Split-Split-Split Plot Error	150	1256.8750	8.3792			
Total	359	13269.0625				

* 5% level of significance.
** 1% level of significance.

APPENDIX XIV

TYPICAL DIFFERENCES IN POTATO CHIP COLOR DUE TO WATER AND STEAM BLANCHING

TYPICAL DIFFERENCES IN POTATO CHIP COLOR DUE TO WATER AND STEAM BLANCHING

Peeled Tubers		Unpeeled Tubers	
Steam Blanched	Water Blanched	Steam Blanched	Water Blanched
37.5	44.3	34.0	39.7
35.5	44.3	36.1	42.0
37.6	46.5	40.3	41.5
38.3	48.1	37.3	43.2
37.3	46.4	36.6	41.4
35.8	44.0	36.4	44.3
38.3	45.8	33.7	41.9
36.3	44.2	40.6	40.6
Mean 37.1	45.4	36.9	41.8

Mean Difference Between Water and Steam Blanch:

Peeled: 8.3

Unpeeled: 4.9