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To the Graduate Council:

I am submitting herewith a thesis written by Amada Pei-an Sun entitled "Relationship of Seed Coat Composition to Water Absorption of Dried Beans, Phaseolus Vulgaris." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology.

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RELATIONSHIP OF SEED COAT COMPOSITION TO WATER ABSORPTION
OF DRIED BEANS, PHASEOLUS VULGARIS

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Amada Pei-an Sun

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ABSTRACT

Five varieties of two lots each of dried beans (Phaseolus Vulgaris) were used to study rate of water imbibition and time required for hydration. Soak-time predictability curves were constructed for each variety. Skins of the beans were removed and analyzed for calcium, protein, pectin and fat content. Correlations were determined between chemical component of the skins and hydration and shear resistance.

Initial moisture content was found to be much lower than the supplier's specifications. Significant differences were found among lots within varieties and among varieties indicating that pre-soak treatments exert some influence on hydration of dried beans. This agrees with the findings of other workers that production area and relative harvesting, drying and storage conditions influencing final moisture content of dried beans influence their hydration rate. Significant variations were found among varieties in time required to attain 50 percent moisture. Black Eye and Navy required less than one-third of the time required by other varieties indicating that chemical and physiological differences among varieties effect both rate of water absorption and hydration time. Shear resistance varied inversely with moisture content. Although wide variations in calcium, protein, pectin and fat content of skins were found between the different varieties, only fat and protein were found to be significantly related to moisture content.

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CHAPTER I

INTRODUCTION

Much of the world's protein comes from vegetable sources. Legumes seeds (pulses) are the most important source of future vegetable protein and their utilization will undoubtedly increase as population increases and living standards improve.

In the areas of Asia, Africa, and South America, animal protein are practically non-existent in the diet of large segments of the population. In these areas, grain crops are the major contributor of protein to the diet. In certain eco-social groups in the U. S., dried beans constitute the major source of protein in the diet due to difference in price between animal and plant protein.

Although, dried beans must continue as the major source of protein on a world wide basis and continue to contribute significantly to the U. S. diet, per capita consumption of dried beans in the U. S. is low and is declining. This is true regardless of the fact that the per unit cost of legume protein is only a fraction of the per unit cost of animal protein. This is probably due in part to the fact that beans and similar legumes are consumed without the benefit of commercial processing thus suffering from the lack of convenience and imaginative variety of different usages generally associated with commercially processed products.

A major problem associated with utilization of dried beans is one of water permeability of the dried beans. Whether processed commercially or in the home, the time required to hydrate the product is too

long. Many research hours have been spent in attempting to elucidate the cause of slow permeability and to speed up the process of hydration. However, much confusion and disagreement still exists.

The objective of this investigation was to study the rate of water absorption and firmness of different varieties of dried beans and to determine the relationship between seed coat composition and the rehydration rate of dried beans.

CHAPTER II

LITERATURE REVIEW

Permeability is one of the most important factors influencing the germination and cooking quality of beans or seeds. Problems related to the permeability of seeds have consistently attracted investigators.

Most of the studies on permeability of seed coats have been done from the standpoint of germination (28),* but are closely related to the problems involved in the cookery of seeds used for food. From the standpoint of both cookery and germination of the bean seed, differences in permeability may be grouped under three headings: 1) those due to structure or chemical variation initially in the seed coats; 2) those resulting from environmental conditions during harvesting and storage; 3) those due to the effect of chemical solutions or solution other than pure water. For the present interest, the review will be mainly restricted to those directly related to this research.

Crocker and Barton (8) in their book "Physiology of Seeds" discussed the problems of permeability of seeds in general. The factors such as variety of seed, seed coat, moisture content, structure and chemical compositions of the seed and temperature were included in their discussions.

Pammel (26) reported the presence of a "cuticle" containing a fatty material repellent to water and covering the legume seeds. He

*The numbers in parentheses represent similarly numbered references in Bibliography.

concluded that the greater part of the water was taken up by the micropyle and hilar groove. Since then, many researchers have conducted studies in this area. The cause of impermeability in seeds has been reported to be due to the embryos in some seeds, but in most cases it is related to the structure and nature of seed coat. Most of the research studies emphasized the structure rather than the chemical composition of the seed coat. In 1920 Coe and Martin (6) made an extensive study of the structure and chemical nature of the seed coat. They found that differences in permeable and impermeable Sweet-clover seeds were due to physical rather than chemical structure. They concluded that the cuticle was permeable and that the portions of the epidermal cells in the region of the light line constituted the impermeable layer. It should be noted that their conclusion disagreed with the results presented by Watson (30), who reported the cuticle as the impermeable layer.

Hyde (16) studied the function of the hilum in some Papilionaceae in relation to the permeability of the testa and concluded that when relative humidity was low the fissure in the hilum opened permitting the seed to dry out; when the relative humidity was high the fissure closed obstructing the absorption of moisture. This conclusion coincided with those given by Honma and Denna (15). They also found that the hilum operates as an hygroscopically activated valve and it plays an important part in the impermeability phenomenon studied.

Smith and Nash (27) studied the water absorption of soy beans. They stated that water absorption is influenced by the initial moisture level in the beans; the lower the moisture the slower the rate of water

absorption and the presence of hard shell beans also reduces the rate of water absorption.

It has frequently been observed that dry beans which have been stored for some time may take longer to cook than freshly harvested beans. The early observations (7, 9, 20, 27, 28) indicated that time, temperature and moisture content all influence the ease with which stored dry beans can be cooked. Burr et al. (3) presented a more systematic investigation of these factors. They reported that the beans under high temperature, high moisture content and long storage contributed to impaired cookability in pinto and sanilac beans. Crean and Haisman (7) stated that the incidence of seed peas which are extremely slow to take up water when soaked is shown to be directly related to the initial moisture content of peas. They reported that impermeability to water can be induced by drying the peas to less than 15 percent moisture. The change is reversible and impermeable peas kept under a high humidity regain their permeability as their moisture content rises. Nutile and Nutile (23) showed that the impermeability condition in beans can be induced or eliminated by systematically changing the relative humidity of the storage atmosphere. In a short review, Harrington (14) recorded that imbibition could always be induced in beans if the seed coat were scratched and also showed that the number of hard seed was directly related to the moisture content and could be increased or decreased by varying the humidity.

Morris et al. (22) using several strains of Great Northern beans studied: 1) rate of water absorption, 2) percentage of hard shell beans

after 5 and 24 hours of soaking, 3) effectiveness of hot water treatment on the elimination of hard shell beans cooking quality, 4) processing quality. He reported that the hot water treatment greatly accelerated the rate of water uptake and reduced the percentage of hard-shell beans markedly.

Lebedeff (17) investigated the hereditary differences in hard seed coat development. He reported that the condition of impermeability was hereditary, although climate and nutrition contributed to its occurrence. By plant breeding and selection, strains have been developed that contain practically no hard shell beans when grown under favorable conditions.

The chemical treatment of hard shell beans has been extensively examined and discussed (11, 28). Various treatments, such as treatment of seeds by concentrated sulfuric acid to increase the percentage of germination (11, 22), and scarification of the seed coat to increase the rate of water imbibition has been recommended. Several authors (22,28) reported the use of some kind of heat treatment prior to soaking as a very effective, practical and convenient means of preparing hard shell beans that are to be processed for food. Greenwood (12) and Snyder (28) found the use of baking soda in either the soaking or cooking water to be an effective means of softening the seed coats of pinto, Great Northern and Navy bean.

Snyder (28) indicated that the pectic constituents which appear to be in the form of pectic acid or pectates are important factors in affecting the permeability of the seed coat and its capacity to soften

readily. She reported that sodium bicarbonate, a solvent of pectic acid, softened the seed coat and that hydrochloric acid, calcium and magnesium salts harden the seed coats. It appeared that the pectic materials bound the cellulose so densely that water was prevented from passing through the seed coats.

Ott and Ball (25) showed a correlation between the absorption of water by beans and the pectin content of their skins. It should be noted that Watson (30), working with a number of leguminous species, was unable to find uniformity in chemical composition and structure or a relationship between chemical composition and impermeability of seeds.

CHAPTER III

MATERIALS AND METHODS

I. SOURCE AND PREPARATION OF DRIED BEANS

In this investigation, an effort was made to study the rate of water absorption and chemical composition of the seed coat of five varieties of dried beans (Phaseolus Vulgaris) and the possible relationship between the chemical composition and permeability. The beans used in this research were supplied by Bush Brothers' Canning Plant, Dandridge, Tennessee. Two ten pound samples, representing two growing areas, of each variety were received. The varieties, lot numbers, origins and the original moisture content of beans are given in Table I. A comparison of the moisture content between stated and determined values are shown in Table II. A considerable difference in moisture content was found to exist between the two values in most of the bean varieties. The difference may be due to the storage conditions and time. The beans were placed in paper bags and stored at 40°F until additional analyses were performed.

Water Absorption

Rate of water absorption was determined by soaking 275 gram aliquots of beans from each lot in two liters of distilled water at ambient temperature for 1, 2, 3, 4, 5 and 24 hours. After each time interval, an approximate 60 gram aliquot of the partially hydrated beans were removed for moisture and shear resistance determination. Gloyer (11)

TABLE I
VARIETY, ORIGIN AND ORIGINAL MOISTURE AND FAT
CONTENT OF DRIED BEANS

Variety	Lot No.	Origin	Moisture Content percent	Fat Content percent
Great Northern	52	Alliance, Nebraska	10.23	1.15
Great Northern	17	Morrill, Nebraska	11.48	1.08
Navy Bean	45	Sunfield, Michigan	17.25	0.95
Navy Bean	54	Gagetown, Michigan	14.02	1.68
Black Eye	92	San Antonio, Texas	12.94	1.11
Black Eye	106	Wasco, California	12.87	1.00
Light Red Kidney	29	Clifton Springs, N. Y.	17.35	0.92
Light Red Kidney	57	Merrill, Michigan	15.09	1.02
Baby Butter	116	Crows Landing, California	10.60	0.17
Baby Butter	8	Vernalis, California	10.01	0.22

TABLE II
INITIAL MOISTURE CONTENT OF BEANS

Variety	Lot No.	Moisture Content Percent (Supplier's Values)	Moisture Content Percent (Determined)
Great Northern	52	10.23	7.85
Great Northern	17	11.48	9.79
Navy Beans	45	17.25	6.10
Navy Beans	54	14.02	5.58
Black Eye	92	12.94	8.55
Black Eye	106	12.87	10.12
Light Red Kidney	29	17.35	8.97
Light Red Kidney	57	15.09	8.84
Baby Butter	116	10.60	5.52
Baby Butter	8	10.01	3.25

reported that the number of hard shells may vary with variety. No attempt was made to determine the number of hard shells in this study, however, every effort was made to exclude hard shells, and beans with damaged testa for all determinations following hydration. The water absorption experiment was replicated three times.

Moisture

Moisture was determined according to AOAC method (1) for cereal crops. After removal from the soaking bath, the beans were lightly rolled between two sheets of water absorbing tissue to remove all surface water, macuated by putting through a food chopper, and weighed into tared moisture dishes. Triplicate samples were weighed from each lot for each time interval. The dishes were dried in a vacuum oven at 70°C and 20 inches of mercury for 16 hours. Loss of weight minus original moisture content was recorded as moisture of rehydration.

Shear Resistance

The Allo-Kramer Shear Press model SP-12 with a Warner-Bratzler type (single blade) cell was used to determine shear resistance. Sample size consisted of eight beans aligned with base orifice in such manner as to cause blade to shear transversely across the mid-section of the beans. Either a 1000 or 250 pound test ring, dictated by force required, with a 19.5 second thrust was employed. Dial readings were recorded and converted to actual pounds of force applied in shearing sample. Several determinations were made at each soaking time interval for each lot and an average value determined. The experiment was replicated three times.

Fat Content

Fat of total bean was determined by AOAC (1) Soxhlet Ether Extract method using a 10 gram sample. The sample was covered with ether and heat applied for 5 hours. Results were recorded as total ether extract.

II. PREPARATION OF DRIED BEAN SKINS

Chemical composition of bean skins was determined on variety and not on lots within each variety. Equal portions of each lot within a variety were mixed and an aliquot sample drawn for chemical analysis of each variety. The beans were soaked in distilled water until the skin could be removed from the cotyledons. The skins were dried in an oven at 70°C overnight. A Wiley Mill with a No. 20 mesh screen was used to grind the dried skins. The ground skins were stored in a sealed glass jar until further analysis.

Moisture

Ten grams of skins were used to determine the moisture content. The experimental procedure used was similar to that of total beans.

Fat

Eight grams of skins were used to determine the fat content. The experimental procedure used was similar to that of total beans.

Pectin

The Versene-Pectinase extraction method of McCready and McComb (20) was employed to analyze the pectic content of bean skins. Five grams of

skins were extracted with 200 ml of 0.5 percent versene solution, adjust the PH to 5.0, then 0.1 gram of pectinase was added. One ml of 0.15 percent of Carbazole reagent was used in this experiment. The colorimetric method was used to determine the intensity of color at 520 mm wave length.

Calcium

The method and procedure given by National Canners Association Research Laboratories (23) was used to determine the calcium content in bean skins. It may be noted that after heating the solution was removed from the hot plate and allowed to stand at room temperature for at least 4 hours. When titrated with KMnO_4 , the first sample should be titrated very slowly at first, allowing sufficient time for one drop of permanganate to be completely decolorized before adding the next drop, since manganous ions which are necessary to catalyze the reaction are not present at the start of the titration. Subsequent samples may be titrated more rapidly by adding a small amount of the previously titrated sample (containing manganous ions) to the sample to be titrated. Five grams of sample were used in this experiment.

Protein

The Kjeldahl method (1) was used to determine the total nitrogen of bean skins. Protein content was calculated by multiplying percent nitrogen by the factor of 6.25.

III. STATISTICAL ANALYSIS

The following effects were tested by means of the analysis of variance:

1. Effect of variety, replication of test and soaking time on the firmness of beans.
2. Effects of variety, replication of test and soaking time on the moisture content of beans.
3. Effect of lots, replication of test and soaking time on the moisture content of beans.
4. Effect of variety and replication of test on the pectin content of beans' skins.
5. Effect of variety and replication of test on the protein content of beans' skins.
6. Effect of variety and replication of test on the calcium content of beans' skins.
7. Effect of variety and replication of test on the fat content of beans' skins.
8. Effect of variety and replication of test on the moisture content of beans' skins.

The computer program SAS (2) on the IBM 360 digital computer (The University of Tennessee Computing Center) was used to perform the analysis of variance calculations.

Calculation for Duncan's multiple range test was performed for the following effects:

1. Effect of variety on the firmness of beans as measured by shear.
2. Effect of soaking time on the firmness of beans as measured by shear.
3. Effect of variety on the moisture content of the soaked beans.
4. Effect of soaking time on the moisture content of the soaked beans.
5. Effect of variety on the pectin content of beans' skins.
6. Effect of variety on the protein content of beans' skins.
7. Effect of variety on the calcium content of beans' skins.
8. Effect of variety on the fat content of beans' skins.
9. Effect of variety on the moisture content of beans' skins.

An IBM subroutine, "Duncan's Multiple Range Test," available in The University of Tennessee computing library was used to perform these calculations.

The following correlation analysis were performed:

1. Pectin content of bean skins were correlated with firmness of beans.
2. Protein content of bean skins was correlated with firmness of beans.
3. Fat content of bean skins was correlated with firmness of beans.
4. Calcium content of bean skins was correlated with firmness of beans.
5. Moisture content of bean skins was correlated with firmness of beans.

6. Pectin content of bean skins was correlated with moisture content of beans.
7. Protein content of bean skins was correlated with moisture content of beans.
8. Fat content of bean skins was correlated with moisture content of beans.
9. Calcium content of bean skins was correlated with moisture content of beans.
10. Moisture content of bean skins was correlated with moisture content of beans.

In the analysis of variance, the statistical significance is shown where calculations were significant. The statistical significance within mean differences in Duncan's Multiple range test was calculated at the 0.01 level of probability.

CHAPTER IV

EXPERIMENTAL RESULTS

I. RATE OF WATER ABSORPTION AND FIRMNESS OF BEANS

Rate of Water Absorption

The rate of water absorption for all varieties investigated were determined from plots of moisture content against soaking time. Figures 1 through 5 illustrate these plots. The absorption rates are the tangents of the curves and a function of soaking time. At any specific time, the corresponding absorption rate can be easily determined. The initial rate of water absorption of each lot and variety of beans was determined at 0 hour and the results are given in Table III.

The data in Figures 1 through 5 illustrate that all varieties and lots of beans absorbed the largest percentage of total water absorbed within the first two hours of soaking. The Black Eye and Navy varieties had the highest average initial rate of water absorption with 82.5 and 53.5 percent per hour, respectively. This resulted in 86 and 83 percent of total water absorbed in a 24 hour period being absorbed within one hour by the Black Eye and Navy varieties, respectively. By comparison, Baby Butter, Great Northern and Light Red Kidney varieties absorbed 82, 80 and 75 percent, respectively, of total water absorbed in 24 hours within 2 hours. The rate of water absorption decreased rapidly after one hour in the Black Eye and Navy varieties and after 2 hours in the Baby Butter, Great Northern and Light Red Kidney varieties.

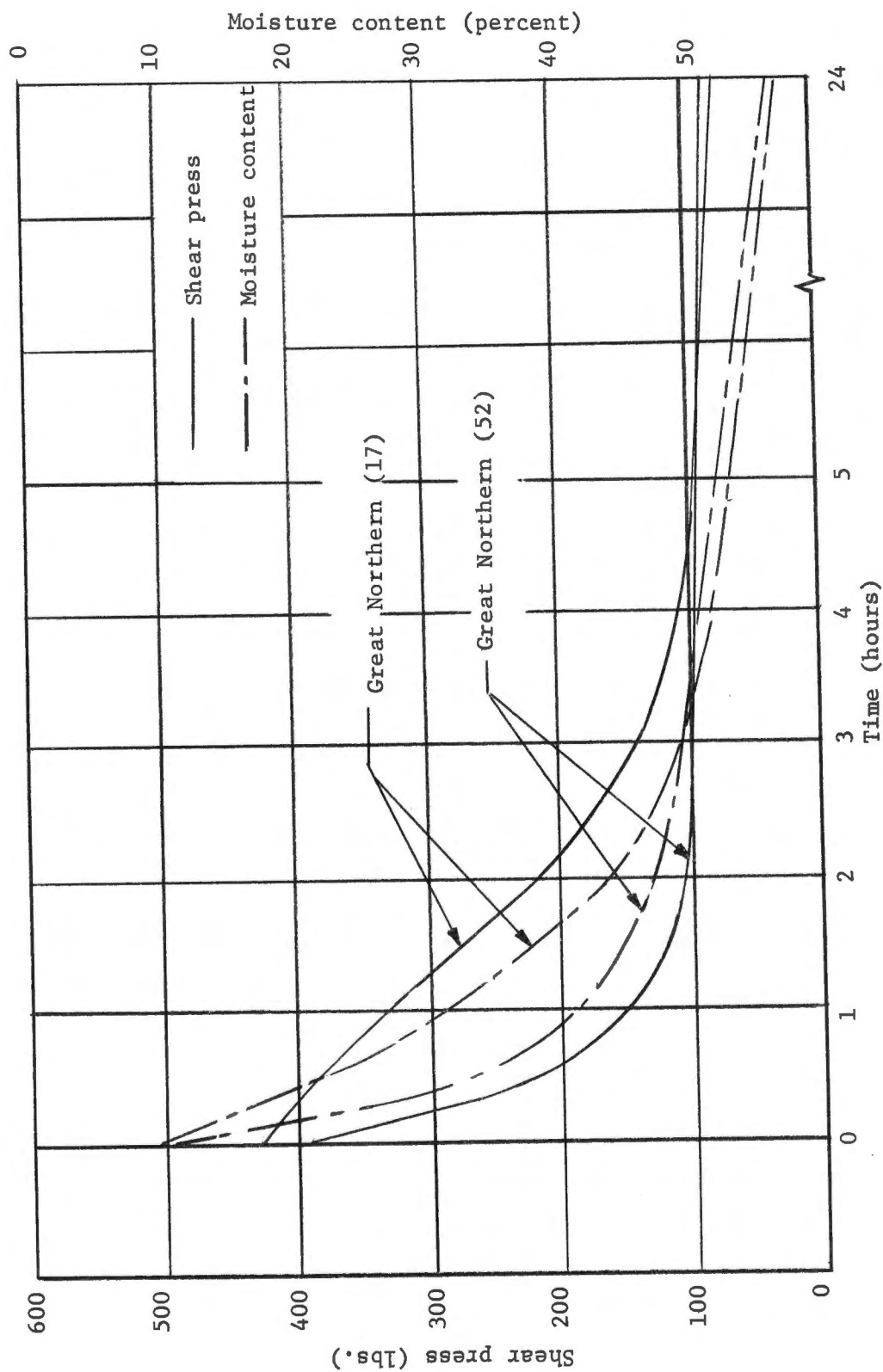


Figure 1. Firmness and moisture content vs. soaking time of great northern.

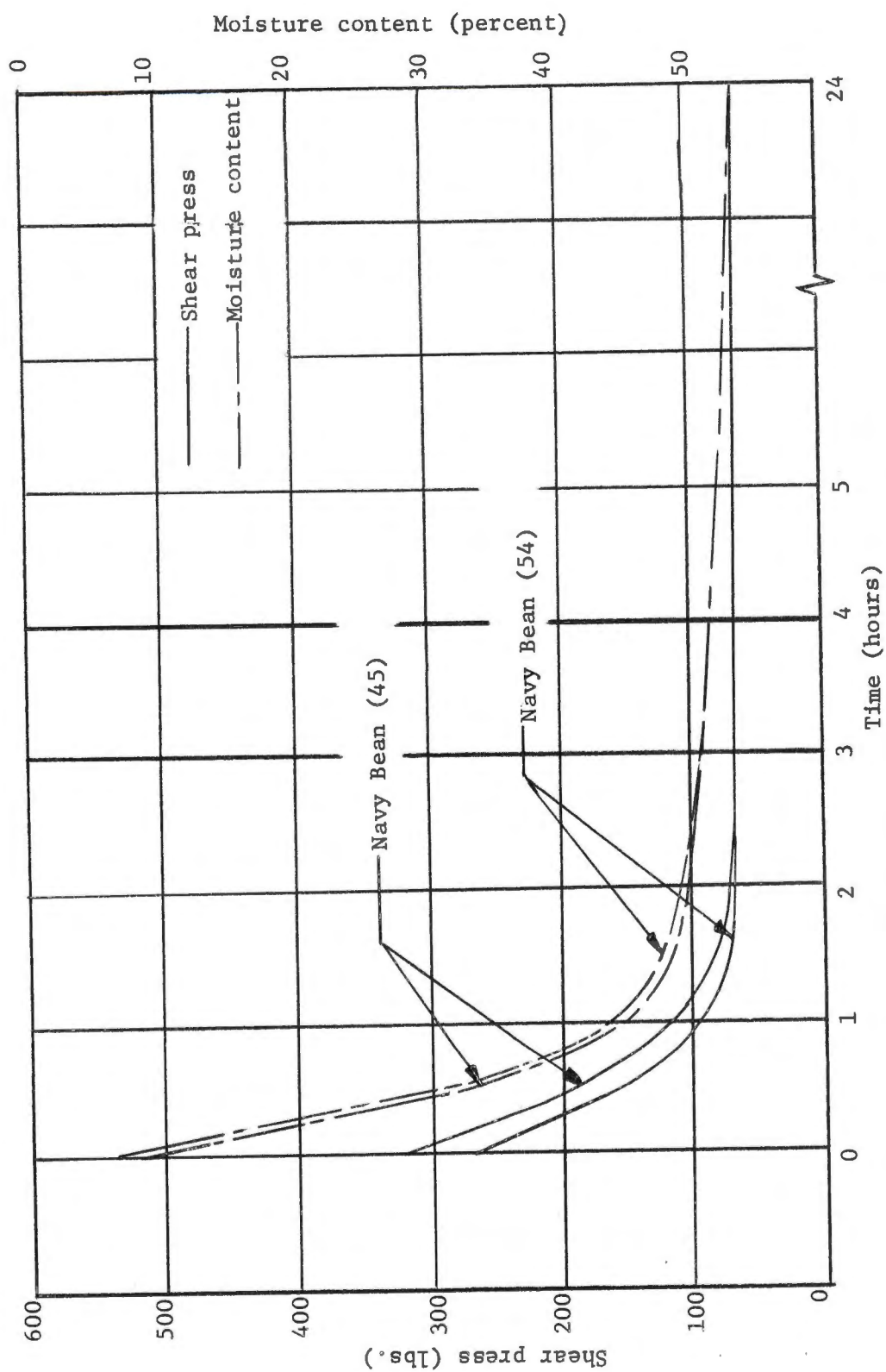


Figure 2. Firmness and moisture content vs. soaking time of Navy bean.

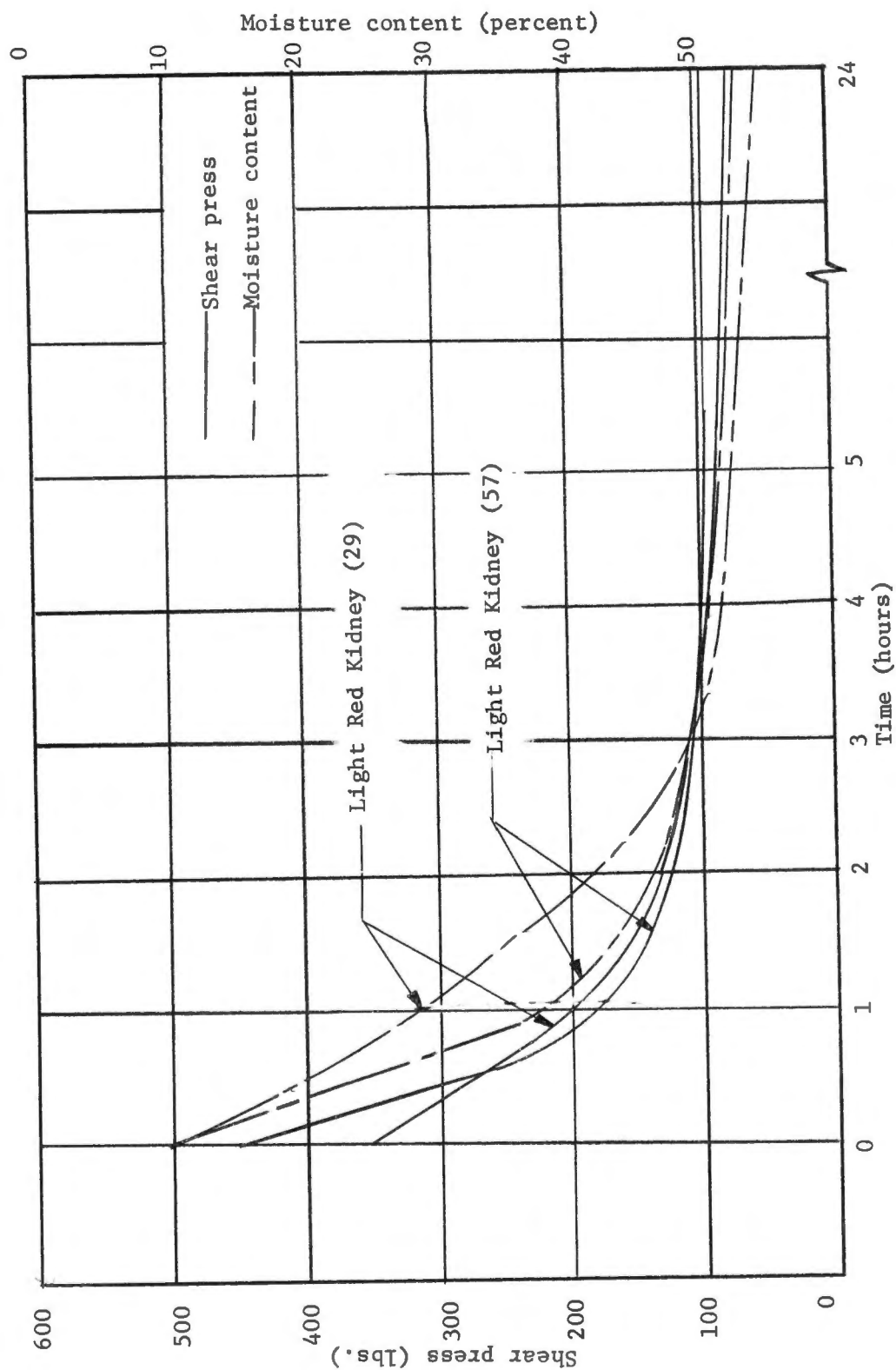


Figure 3. Firmness and moisture content vs. soaking time of light red kidney.

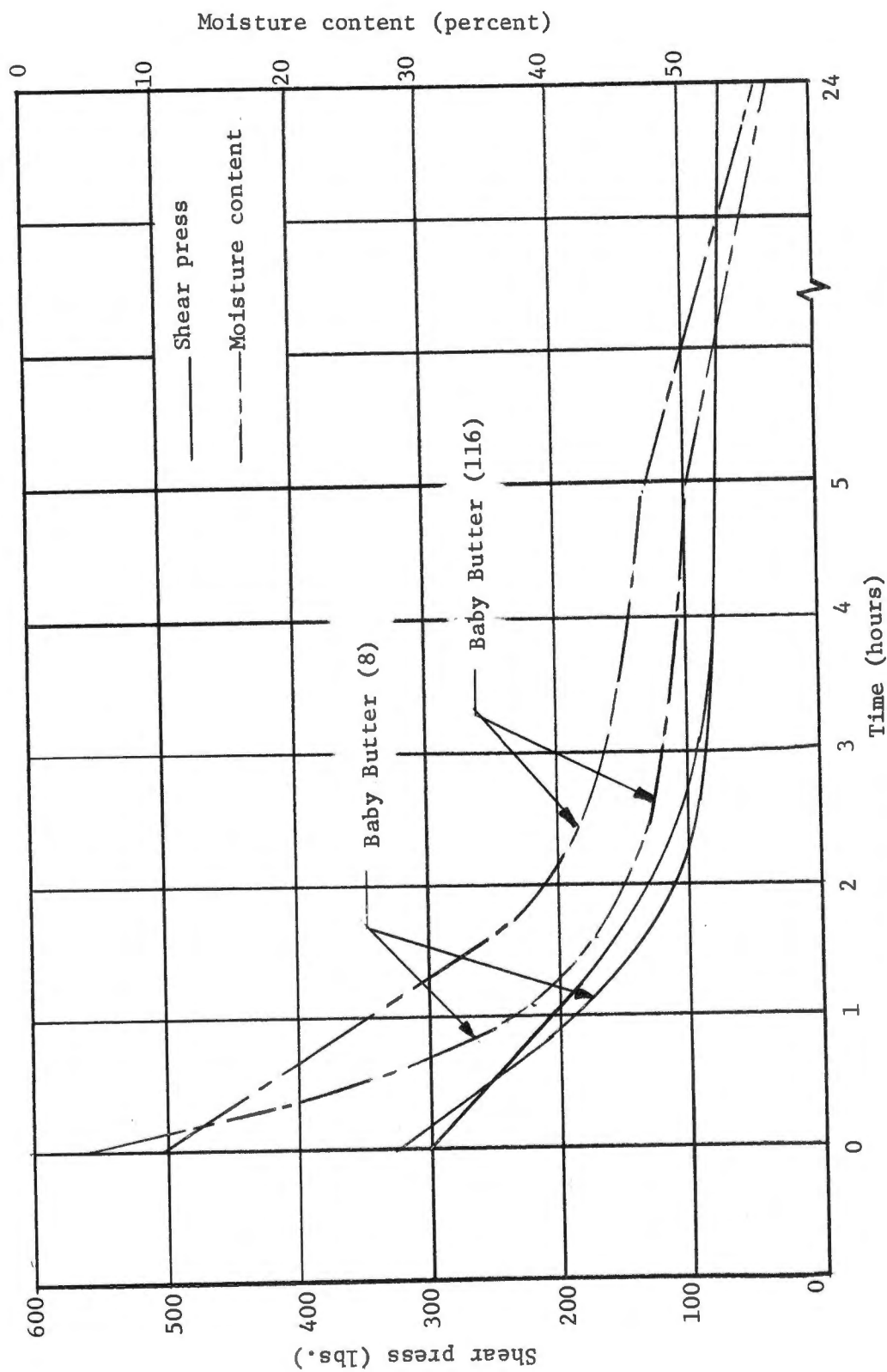


Figure 4. Firmness and moisture content vs. soaking time of baby butter.

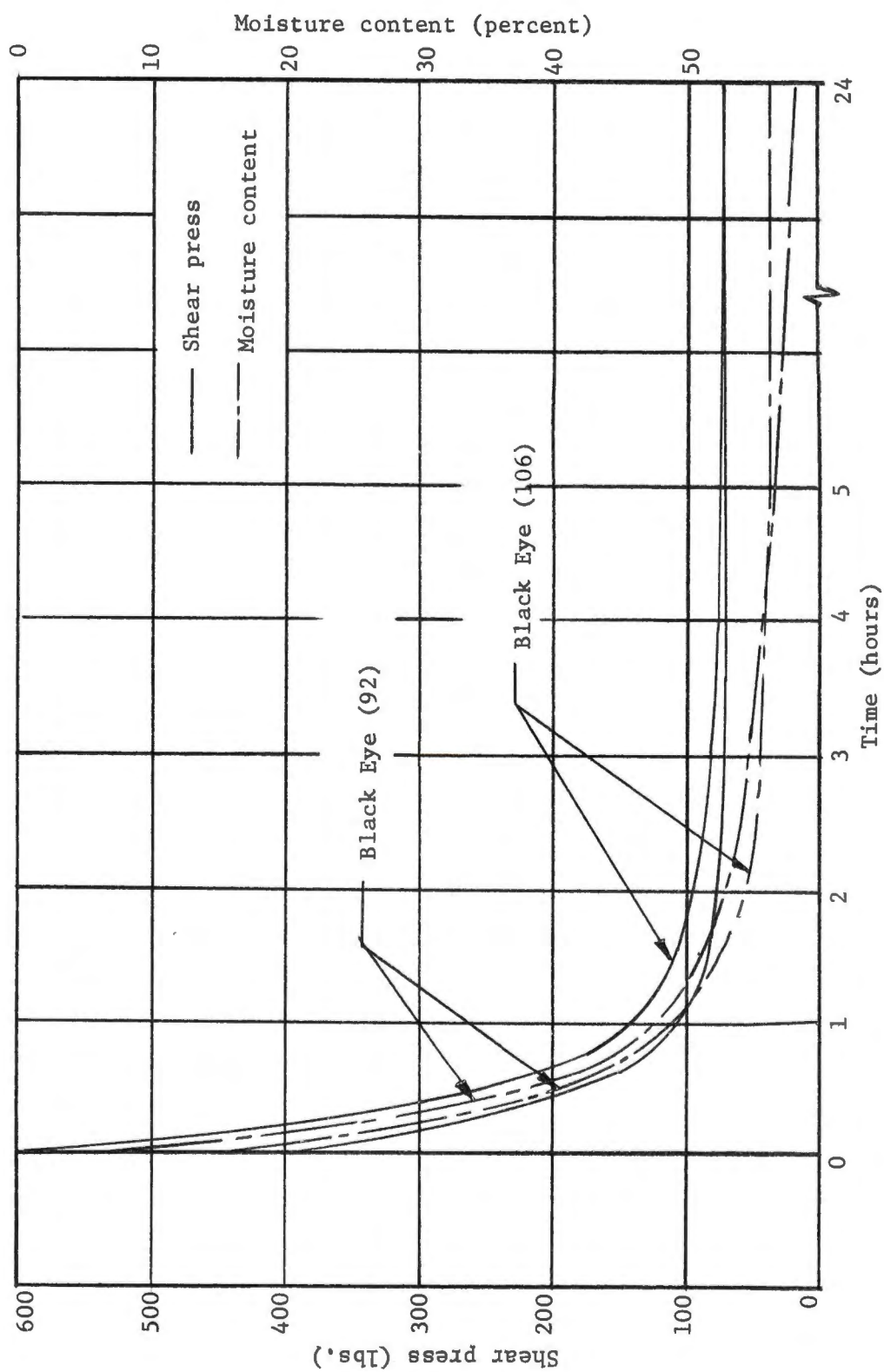


Figure 5. Firmness and moisture content vs. soaking time of black eye.

TABLE III

RATE OF WATER ABSORPTION AMONG VARIETIES AND LOTS
OF DRIED BEANS AT 0 AND ONE HOUR

Variety	Lot No.	Rate of Water Absorption percent/hr	
		0 hr	1 hr
Great Northern	52	63.3	10.4
Great Northern	17	25.0	16.7
Navy Bean	45	56.5	12.3
Navy Bean	54	51.5	12.0
Black Eye	106	95.0	11.0
Black Eye	92	70.0	10.0
Light Red Kidney	29	23.2	14.3
Light Red Kidney	57	32.0	18.2
Baby Butter	116	16.0	15.6
Baby Butter	8	49.0	16.0

The data also show differences in water absorption rates between different lots of the same variety. For example, Great Northern and Baby Butter showed a 38 and 33 percent difference in water absorption rate between lots, respectively. Other varieties showed similar but lesser differences. The different lots of beans were grown in different production areas. The differences in hydration rates could be due to differences in initial moisture content as related to area of production, processing, or storage conditions. The difference in rate of hydration was equalized in one hour in Navy and Black Eye varieties, in 3 hours Light Red Kidney and Great Northern varieties, but persisted through a 24 hour soaking period in the Baby Butter variety.

Results of analysis of variance to determine the effect of variety, replication and soaking time on the moisture content of beans are shown in Table IV. The data indicates soaking time to be the most significant factor influencing the moisture absorption of bean varieties. There was a significant difference among varieties at the 0.01 level. The interaction of variety and soaking time was significant at the 0.05 level. Replication was not statistically significant. Table V summarizes the results of the analysis of variance of the effect of lot, replication and soaking time on the moisture content of beans. Lot, soaking time and their interactions were found to be significantly related to moisture content of the beans. Results of Duncan's Multiple range test of the effects of variety, moisture and soaking time are presented in Table VI and Table VII.

TABLE IV

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS AMONG
VARIETIES, REPLICATION AND SOAKING TIME ON
THE MOISTURE CONTENT OF BEANS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Variety	4	5380.12	1345.03	220.554**
Rep.	2	0.338	0.169	0.0277
Time	6	152746.438	25457.740	4174.492**
Variety x Rep.	8	182.914	22.864	3.7492
Variety x Time	24	4019.053	167.461	27.4597
Error	585	3567.567	6.098	
Total	629	165896.429	263.7463	

**Statistical significance at the 0.01 percent level of probability.

TABLE V

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
AMONG LOTS, REPLICATION AND SOAKING TIME ON
THE MOISTURE CONTENT OF BEANS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Lot	9	6312.731	701.4145	488.624**
REP.	2	0.338	0.1692	0.11785
Time	6	152746.49	25457.75	9999.99**
Lot x REP.	18	260.666	14.482	10.088**
Lot x Time	54	5801.114	107.428	74.837**
Error	540	775.164	1.4355	
Total	629	165896.5	263.75	

**Statistical significance at the 0.01 percent level of probability.

TABLE VI

RESULTS OF DUNCAN'S MULTIPLE RANGE TEST FOR THE EFFECTS
OF VARIETIES ON THE MOISTURE CONTENT AND
FIRMNESS OF THE SOAKED BEANS

Variety	<u>Firmness</u> Mean	<u>Moisture</u> <u>Percent</u> Mean
Great Northern	168.818i	43.859a*
Navy	101.507m	44.244a
Black Eye	56.848n	47.728b
Light Red Kidney	150.678ij	41.740c
Baby Butter	140.078j	38.889d

*Means followed by the same letter within a column are not significantly different at 0.01 level of probability.

TABLE VII

RESULTS OF DUNCAN'S MULTIPLE RANGE TEST FOR THE EFFECT
OF SOAKING TIME ON THE MOISTURE CONTENT AND
FIRMNESS OF THE SOAKED BEANS

Soaking Time hour	<u>Firmness</u> Mean	<u>Moisture</u> <u>Percent</u> Mean
0	297.940t	7.456f*
1	151.340s	38.350d
2	106.055i	46.355e
3	89.994ijk	50.027c
4	78.678jmn	51.515bc
5	73.644kmp	52.753b
24	67.439np	56.586a

*Means followed by the same letter within a column are not significantly different at 0.01 level of probability.

Total quantity of water absorbed by dried beans is variety dependent as illustrated in Table VI. When all soak times were combined for each variety and their means tested against absorbed water by Duncan's Multiple range test, significant differences were found among all varieties. Likewise, total water absorbed by dried beans is a function of soaking time as depicted in Table VII. For example, the moisture content of Navy beans varieties from 5.8, 45.5, 50.3, 51.9, 52.9, and 54.8 percent for time of 0, 1, 2, 3, 4, 5 and 24 hours as compared with Great Northern with moisture contents of 8.8, 36.2, 43.2, 50.3, 52.4, 51.6 and 57.8 percent at same time intervals. Duncan's Multiple range test indicates a significant difference among all soaking time except for the hours of 4, 5 and 6.

Firmness

It is thought that the moisture content is directly related to the firmness of beans. The firmness was determined by measuring the shear resistance of the beans. The experimental results of firmness, due to the convenience of comparison with moisture content are also plotted in Figures 1 through 5. All curves of firmness vs. soaking time are parallel to those of moisture content. Difference in firmness between lots within varieties was greater with Great Northern than with all other varieties. This strongly implies that firmness and moisture content are closely related. For interest, the initial decreasing rate of shear force was determined and the results are presented in Table VIII. By comparing Tables III and VIII and Figures 1 through 5, it can be seen that the faster the beans absorb moisture the quicker they loose shear resistance.

TABLE VIII

DECREASING RATE OF SHEAR RESISTANCE AMONG VARIETIES
OF DRIED BEANS AT 0 AND ONE HOUR

Variety	Lot No.	Rates of Shear Resistance lb/hr	
		0 hr	1 hr
Great Northern	52	380	89
Great Northern	17	106	102
Navy Bean	45	300	95
Navy Bean	54	245	60
Black Eye	106	160	290
Black Eye	92	126	260
Light Red Kidney	29	148	111
Light Red Kidney	57	290	107
Baby Butter	116	93	91
Baby Butter	8	147	111

Results of analysis of variance of the effect of variety, replication and soaking time on the firmness of beans as measured by shear are presented in Table IX. Variety, soaking time and the interaction of variety and soaking time were all found to be significant at the 0.01 percent level of probability. Table VI presents the results of Duncan's Multiple range test for the effect of variety on the moisture content and firmness of beans and Table VII presents similar results on the effect of soaking time on the moisture content and firmness of beans. Navy and Black Eye varieties were found to be significantly different from each other (Table VI) and all other varieties. Great Northern and Light Red Kidney were not significantly different from each other. Light Red Kidney and Baby Butter were not significantly different from each other. Significant differences in firmness were found among soaking times between varieties up to 3 hours (Table VII). No significant differences were found after 4 hours except between soaking time of 4 hour and 24 hours. This value could possibly be due to sampling error.

II. CHEMICAL COMPOSITION OF SEED COAT

Moisture

The moisture content in bean skins was determined and the experimental results are presented in Table X. Black Eye variety had the highest moisture content with 3.627 percent. Navy and Baby Butter varieties had 0.623 percent respectively. Results of analysis of variance of the effect of variety and replication on the moisture content of bean skins is given in Table XI. Variety was found to be significant

TABLE IX

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
AMONG VARIETIES, REPLICATION AND SOAKING TIME
ON THE FIRMNESS OF BEANS AS MEASURED BY SHEAR

Source	D. F.	Sum of Squares	M. S.	F-Ratio
Variety	4	1352683.66	338170.915	418.046**
REP.	2	45.38	22.688	0.02805
Time	6	4863247.62	810541.270	1001.989**
Variety x REP.	8	3472.57	434.071	0.537
Variety x Time	24	792619.33	32025.805	40.826**
Error	795	643100.88	808.932	
Total	839	7655169.43	9124.159	

**Statistical significance at the 0.01 percent level of probability.

TABLE X
CHEMICAL COMPOSITION OF BEAN SKINS

Variety	Pectin Percent	Protein Percent	Fat Percent	Calcium Percent	Moisture of Skin Percent
Great Northern	78.3	4.262	0.245	18.240	2.360
Navy Bean	88.0	4.542	0.485	23.220	0.623
Baby Butter	30.3	4.513	0.054	4.370	0.697
Light Red Kidney	59.0	5.318	0.156	3.060	1.231
Black Eye	58.3	9.032	1.195	6.010	3.623

TABLE XI

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
 AMONG VARIETIES AND REPLICATION ON THE MOISTURE
 CONTENT OF BEANS' SKINS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Variety	4	19.5409	4.8852	506.6809**
Test	2	0.1946	0.0973	10.0916
Error	8	0.0771	0.0096	
Total	14	19.8127	1.4152	

**Statistical significance at the 0.01 percent level of probability.

at the 0.01 percent level of probability. Table XII presents the results of Duncan's Multiple range test for moisture of bean skins. All varieties were found to be significantly different from each other with the exceptions of Navy and Black Eye varieties.

Fat

Fat content of bean skins was determined and the data are presented in Table X. Black Eye was found to contain the highest percentage of fat with 1.195 percent. Navy, Great Northern, Light Red Kidney and Baby Butter contained 0.485 percent, 0.245 percent, 0.156 percent and 0.054 percent, respectively.

The results of analysis of variance of the effect of variety on the fat content of bean skins are presented in Table XIII. A significant difference was found among varieties at the 0.01 level. Table XII shows the significance of the differences among all varieties for fat content at the 0.01 level.

Pectin

Pectin content of bean skins are presented in Table X. Navy, Great Northern, Light Red Kidney, Black Eye and Baby Butter varieties had 88.0, 78.3, 59.0, 58.3 and 30.3 percent pectin, respectively.

Results of analysis of variance of the effect of variety and replication on pectin content is given in Table XIV. A significant difference was found among varieties at the 0.01 level. Duncan's Multiple range test was performed to determine the significant differences between the means and are given in Table XII. Significance was found among all varieties with the exception of Light Red Kidney and Black Eye varieties.

TABLE XII

RESULTS OF DUNCAN'S MULTIPLE RANGE TEST FOR THE EFFECT
OF VARIETIES ON THE MOISTURE, PECTIN,
PROTEIN, FAT AND CALCIUM CONTENT
OF BEAN SKINS

Variety	<u>Pectin Percent Mean</u>	<u>Protein Percent Mean</u>	<u>Fat Percent Mean</u>	<u>Calcium Percent Mean</u>	<u>Moisture of Skin Percent Mean</u>
Great Northern	78.30a	4.26a	0.25a	18.24a	2.36a*
Navy Bean	88.00b	4.54b	0.49b	23.22b	0.62b
Baby Butter	30.30d	4.51b	0.05c	4.37c	0.70c
Light Red Kidney	59.00c	5.32c	0.16d	3.06d	1.23d
Blacy Eye	58.30c	9.03d	1.20e	6.01e	3.62e

*Means followed by the same letter within a column are not significantly different at 0.01 level of probability.

TABLE XIV

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
AMONG VARIETIES, AND REPLICATION ON THE PECTIN
CONTENT OF BEAN SKINS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Variety	4	5894.4000	1473.6000	112.9195**
Test	2	43.6000	21.8000	1.6705
Error	8	104.4000	13.0500	
Total	14	6042.4000	431.6000	

**Statistical significance at the 0.01 percent level of probability.

Calcium

Table X shows that Great Northern and Navy varieties are rich in calcium content. They contain 18.24 percent and 23.22 percent calcium, respectively. On the other hand, Black Eye, Light Red Kidney and Baby Butter varieties have 6.009, 3.057 and 4.365 percent, respectively. The analysis of variance of the effect of variety and replication on calcium content of bean skins is given in Table XV. A significant difference among varieties was found at the 0.01 level. Table XII shows the significance of the differences among all varieties for calcium content at the 0.01 level.

Protein

Black Eye variety had more protein in the skin than other bean varieties as shown in Table X. The average protein content found in bean skins was approximately 5 percent. Black Eye variety had 9.032 percent and Great Northern, Navy Bean, Baby Butter, and Light Red Kidney had 4.262, 4.542, 4.513 and 5.318 percent, respectively.

The results of analysis of variance of the effect of variety on the protein content of beans is given in Table XVI. A significant difference was found among varieties at the 0.01 level. Table XII shows the significance of the differences among all varieties for protein content at the 0.01 level with the exception of Navy Bean and Baby Butter varieties.

TABLE XV
SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
AMONG VARIETIES AND REPLICATION ON THE CALCIUM
CONTENT OF BEAN SKINS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Variety	4	2508.4959	627.1240	9999.9999**
Test	2	1.0052	0.5026	19.0935
Error	8	0.2106	0.0263	
Total	14	20509.7117	179.2651	

**Statistical significance at the 0.01 percent level of probability.

TABLE XVI

SUMMARY OF THE ANALYSIS OF VARIANCE FOR THE EFFECTS
 AMONG VARIETIES AND REPLICATION ON THE PROTEIN
 CONTENT OF BEANS' SKINS

Source	D. F.	Sums of Squares	M. S.	F-Ratio
Variety	4	47.7876	11.9469	310.0374**
Test	2	0.0344	0.0172	0.4470
Error	8	0.3083	0.0385	
Total	14	48.1303	3.4379	

**Statistical significance at the 0.01 percent level or probability.

III. CORRELATION OF CHEMICAL COMPOSITION AND MOISTURE CONTENT AND FIRMNESS OF BEANS

Correlation coefficient is often used in predicting the relationship between two factors. A statistical determination of the correlation coefficients between 1) the shear press, 2) the moisture content and chemical compositions were made. Results are presented in Tables XVII and XVIII.

The analysis was done for all varieties. The results should be interpreted as the correlation coefficients between moisture content and chemical composition of Phaseolus Vulgaris and not referred to any particular variety. It must be noted that for convenience mean values were used in the analysis and the data analyzed for relationship of moisture against all chemical factors and firmness against all chemical factors.

As discussed in any standard statistics textbook, when the degree of freedom ($n-2$) is small, the correlation coefficients obtained are very sensitive to the experimental data and the correlation coefficients less than 0.5 are not reliable and theoretically not significant. In general the greater the coefficient, the higher the significance.

The computer program SAS (2), available in The University of Tennessee Computing Center, was used to perform the analysis. The correlation coefficients are given in Tables XVII and XVIII.

Minus signs in Table XVII imply that in general, when the content of chemical components in beans increases, the moisture absorption decreases. On the other hand, the positive values in Table XVIII indicate

TABLE XVII

CORRELATION COEFFICIENTS OF MOISTURE WITH PECTIN, PROTEIN,
FAT, CALCIUM AND MOISTURE CONTENT OF BEAN SKINS

Soaking Time hours	Pectin	Protein	Fat	Calcium	Moisture of Skins
0	-0.357	-0.743	-0.936**	-0.697	-0.511
1	-0.034	-0.824	-0.665	-0.098	-0.814
2	-0.286	-0.709	-0.627	-0.260	-0.717
3	-0.395	-0.775	-0.784	-0.464	-0.770
4	-0.358	-0.856**	-0.901**	-0.534	-0.770
5	-0.516	-0.725	-0.806	-0.606	-0.779
24	-0.427	-0.382	0.300	-0.085	0.654

**Statistical significance at the 0.01 percent level of probability.

TABLE XVIII

CORRELATION COEFFICIENTS OF SHEAR PRESS WITH PECTIN, PROTEIN,
FAT, CALCIUM AND MOISTURE CONTENT OF BEAN SKINS

Soaking Time hours	Pectin	Protein	Fat	Calcium	Moisture of Skins
0	0.720	0.094	0.186	0.468	0.425
1	0.219	0.559	0.471	0.202	0.854**
2	0.453	0.123	0.142	0.296	0.626
3	0.511	0.237	0.259	0.359	0.659
4	0.513	0.157	0.144	0.263	0.514
5	0.540	0.041	0.388	0.245	0.419
24	0.757	0.034	0.064	0.420	0.142

**Statistical significance at the 0.01 percent level of probability.

that the firmness increases when content of chemical component increases. An attempt was made to plot the initial rate of water absorption against chemical components such as calcium, fat, pectin, protein and moisture content of bean skins. No significant relationship was found between the chemical components and firmness of dried beans. No significant relationship was found between the chemical components and moisture content of beans. This is possibly due to the complication of the absorption phenomena and the simultaneous dependence upon the many physical and chemical factors.

The asterisks (*) in Tables XVII and XVIII indicate the statistical significance of correlations. It shows that the relation between fat content and moisture absorption at 0 hour and 4 hour soaking time are significant. The correlation of protein content and water absorption at 4 hour soaking time was significant. In Table XVIII there was a significant correlation between moisture of skins and firmness of beans.

CHAPTER V

DISCUSSION

Analysis of variance was made to determine the statistical significance of the factors such as variety, soaking time and their relationship to moisture content and firmness. The results indicate that both soaking time and variety significantly influenced both moisture content and firmness. However soaking time was found to be the most significant factor.

Total quantity of water absorbed by dried beans is variety dependent. For example, the Black Eye and Navy varieties had the highest average initial rate of water absorption with 82.5 and 53.5 percent per hour, respectively. The rates also show differences in water absorption between different lots of the same variety. Great Northern and Baby Butter showed a 38 and 33 percent difference in water absorption rate between lots, respectively. The lot effect diminished after 3 hours in all varieties except for Baby Butter where it persisted throughout the 24 hours period. The differences in hydration rates could be due to differences in initial moisture content as related to area of production, processing, age and storage conditions. Snyder (27) reported that these factors influenced hydration rate. The rate of water absorption decreased rapidly after one hour in the Black Eye and Navy varieties and decreased rapidly after 2 hours in the Baby Butter, Great Northern and Light Red Kidney varieties. The rate of water absorption is reflected in the length of time required for each variety to attain 50 percent moisture content. Black Eye and Navy were highest in water absorption rate and

require 1 and 2 hours, respectively, to attain 50 percent moisture content. Great Northern was intermediate in absorption rate and requires 3.5 hours to reach 50 percent moisture. Light Red Kidney and Baby Butter absorbed water at equal rates however Baby Butter required 2 hours more (5.5) to reach 50 percent moisture than did Light Red Kidney (3.5).

The results show different initial decreasing rates of shear resistance for all varieties. Differences in firmness between lots within varieties was greater with Great Northern than with all other varieties. It is thought that the moisture content is directly related to the firmness of beans. The firmness was determined by measuring the shear resistance of beans. From Figures 1 through 5, all curves of firmness vs. soaking time are parallel to those of moisture content. This strongly implies that firmness and moisture content are closely related. It can be seen that the faster the beans absorbed moisture the quicker they lost shear resistance.

The chemical composition of bean skins were performed by varieties not by lots. Wide variation in chemical composition of skins were found between the different varieties. Great Northern and Navy bean varieties had the highest pectin and calcium content with 78.3 and 88.0 percent of pectin and 18.24 and 23.22 percent of calcium, respectively. Black Eye variety had the highest protein and fat content with 9.032 and 1.195 percent in the skins, respectively.

A primary objective of this study was to determine the importance of the seed coat to ability of seed to absorb water on the hypothesis that seed coat composition might be significantly related to water movement

into the seed. Seed skins were analyzed for calcium, pectin, protein and fat content. Wide variation was found among varieties in chemical composition. However, when correlation analysis was performed between seed coat composition and moisture content, no significant relationships were found to exist. Calcium content, for example, of Great Northern was 18.2 and 23.2 percent for Navy, yet Navy requires 2 hours to reach 50 percent moisture content and Great Northern requires 3.5 hours. Similarly, Navy and Baby Butter had approximately the same protein content but required 2 and 5.5 hours, respectively, to reach 50 percent moisture. This agrees generally with the findings reported by other research workers (24, 30). Possibly insufficient sampling was performed to establish significant relationships. This may be indicated by the fact that a slight but not significant relationship was found between protein and fat contents and total water absorbed. For example, fat was found to be significantly related to moisture content at 0 and 4 hours. No significance was established at other soaking times, however, the data indicate a degree of association between the two factors through 5 hours of soaking. Protein was found to be significantly related to moisture content at 4 hours, and as for fat content, a degree of association was indicated for all soaking times through 5 hours. No significant relationship was found between pectin content of the bean skins and moisture content of the dried beans.

Additional research will be necessary to establish whether or not a relationship exists between seed coat composition and water absorption. However, the results of this study would indicate that other factors may

possibly exert a greater influence on moisture absorption than does seed coat composition.

CHAPTER VI

SUMMARY

The objective of this investigation was to study the rate of water absorption and firmness of different varieties of dried beans and to determine the relationship between seed coat composition and the rehydration rate of dried beans.

Under the conditions of this study the following observations can be made:

1. Initial moisture content of whole beans was found to be lower than reported values and varied with production area (lot) and with variety.
2. Initial rate of moisture absorption varied with lot and with variety. The different hydration rates between lots was probably due to differences in initial moisture content as related to production area, processing, age and storage conditions. Differences between varieties can be attributed to chemical and physiological differences of the beans.
3. Time required to reach 50 percent moisture content varied with variety. For example, Black Eye required 1 hour, Navy 2 hours, Great Northern 3.5 hours, and Baby Butter and Light Red Kidney 5.5 hours to reach 50 percent moisture content.
4. Firmness varied with variety and was inversely related to moisture content.

5. Wide variation in chemical composition of bean skins was found between varieties.
6. Fat was found to be significantly related to moisture content at 0 and 4 hours. No significance was established at other soaking times, however, the data indicate a degree of association between the two factors through 5 hours of soaking. Protein was found to be significantly related to moisture content at 4 hours, and as for fat content, a degree of association was indicated for all soaking times through 5 hours. No significant relationship was found between pectin content of the bean skins and moisture content of the dried beans.
7. No significant relationship was found between the chemical components of the bean skins and firmness of the dried beans.

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APPENDIX

TABLE XIX
SHEAR VALUE OF FIVE VARIETIES OF DRIED BEANS
AT 0, 1, 2, 3, 4, 5 AND 24 HOURS

Variety	Lot No.	Soaking Time							
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.	
(pounds force)									
Great Northern	17	462	304	274	183	119	95	67	
		429	314	233	143	107	94	86	
		382	351	193	119	106	118	69	
		370	356	151	121	123	99	71	
		491	300	292	152	126	93	72	
		489	369	242	178	97	83	78	
		382	327	288	123	97	81	66	
		388	381	224	137	100	106	71	
	Great Northern	52	434	156	102	115	102	102	83
			357	116	116	98	107	87	82
			350	127	106	111	90	99	79
			350	127	106	106	92	93	87
			332	136	94	104	95	88	76
			395	147	89	85	97	93	78
			334	133	99	100	109	90	72
			434	133	109	107	101	87	83
Navy Bean	45	384	44	75	82	91	76	83	
		338	79	77	80	84	64	77	
		348	73	77	73	78	76	85	
		248	64	75	88	87	73	88	
		366	77	69	75	56	70	44	
		254	59	73	72	53	65	43	
		337	43	63	77	59	52	52	
		384	48	78	64	67	62	48	
	Navy	54	290	88	93	72	70	60	56
			225	78	68	84	68	59	62
			256	80	69	65	75	69	69
			306	77	78	76	64	46	69
			251	73	75	68	65	46	66
			282	88	70	81	61	66	71
			290	81	64	67	78	62	61
			225	75	66	63	61	66	68

TABLE XIX (Continued)

Variety	Lot No.	Soaking Time							
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.	
(pounds force)									
Black Eye	106	156	56	49	54	41	39	53	
		137	62	41	55	41	50	42	
		133	51	48	54	40	45	48	
		161	50	46	51	50	41	45	
		135	55	44	50	41	44	43	
		148	55	49	50	44	41	45	
		156	54	38	52	45	44	46	
		137	54	53	48	44	44	38	
	Black Eye	92	110	52	45	40	41	47	40
			119	45	47	43	40	41	41
110			49	40	44	48	45	37	
108			57	44	46	40	39	46	
117			63	47	48	48	46	43	
115			50	54	43	43	39	41	
110			42	46	48	48	46	48	
120			49	43	46	46	43	50	
Light Red Kidney		29	313	178	118	99	100	81	73
			311	152	103	101	96	85	65
	381		202	115	95	93	79	72	
	300		223	118	94	105	91	72	
	385		178	144	135	96	80	78	
	319		208	114	125	98	86	83	
	314		249	113	81	91	89	88	
	312		182	129	93	88	84	74	
	Light Red Kidney	57	513	195	121	106	113	99	93
			422	139	128	105	108	116	89
337			131	115	115	116	112	88	
389			204	120	101	110	95	106	
486			156	140	118	111	109	89	
435			159	132	121	101	106	101	
591			161	115	110	104	98	95	
390			152	118	101	108	87	94	

TABLE XIX (Continued)

Variety	Lot No.	Soaking Time							
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.	
(pounds force)									
Baby Butter	116	310	306	137	86	78	68	68	
		281	215	126	95	83	89	74	
		273	299	121	119	90	81	66	
		273	299	133	94	86	76	68	
		340	152	113	122	79	58	73	
		271	133	143	69	75	73	69	
		277	167	161	98	88	61	61	
		277	171	123	105	81	71	56	
	Baby Butter	8	352	211	97	92	71	73	72
			249	312	82	94	71	64	61
			284	240	126	92	72	73	69
			261	271	90	89	94	86	66
			361	106	100	90	81	79	64
			391	140	106	108	81	82	67
			352	131	97	78	79	71	72
			284	98	122	82	91	77	63

TABLE XX
MOISTURE CONTENT OF FIVE VARIETIES OF DRIED BEANS
AT 0, 1, 2, 3, 4, 5 AND 24 HOURS

Variety	Lot No.	Soaking Time						
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.
percent								
Great Northern	17	9.9	30.6	40.9	50.9	52.8	51.0	57.2
		9.7	29.0	40.9	51.0	52.3	51.4	57.6
			30.6	40.3	49.2	52.4	51.2	57.9
			34.5	48.2	50.1	52.2	51.6	58.0
			34.2	47.3	49.3	51.9	50.6	57.8
			34.0	45.7	49.3	52.9	51.8	57.8
Great Northern	52	7.5	42.3	46.3	50.2	52.6	52.5	57.8
		8.2	42.4	45.7	50.6	52.1	51.8	58.2
			42.5	45.2	50.2	52.6	52.1	58.4
			42.3	47.9	48.3	52.7	53.5	57.1
			42.3	48.0	48.0	52.7	52.9	57.2
			42.6	48.5	48.3	52.5	53.3	57.0
Navy Bean	45	6.1	45.9	48.6	50.2	52.2	53.7	55.3
		6.1	45.3	48.5	50.2	52.1	53.5	55.1
			45.0	48.5	50.0	51.9	53.7	54.9
			45.4	48.2	51.1	51.7	52.8	55.7
			45.6	49.0	50.9	51.2	52.6	55.3
			45.3	48.7	50.8	51.2	52.9	55.1
Navy Bean	54	5.6	45.8	49.0	50.7	51.8	52.3	54.3
		5.6	45.4	49.0	50.6	51.9	52.1	54.7
			45.6	48.6	50.5	51.7	52.2	54.7
			46.6	48.6	50.5	51.7	52.5	54.8
			45.9	47.9	50.3	51.3	52.7	54.8
			45.4	48.3	50.8	51.4	52.0	54.8

TABLE XX (Continued)

Variety	Lot No.	Soaking Time						
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.
percent								
Black Eye	106	10.0	48.0	53.3	54.4	55.8	56.4	58.6
		10.3	48.2	52.9	55.6	55.6	56.9	58.4
			48.1	53.1	54.4	55.6	56.5	57.9
			48.4	55.6	55.5	55.9	56.4	57.6
			48.7	55.6	54.2	56.1	56.3	57.3
			48.8	54.4	54.9	56.5	56.0	57.7
Black Eye	92	8.4	48.9	54.1	55.3	56.5	57.1	57.2
		8.7	48.1	53.7	55.2	56.6	57.5	57.1
			47.9	53.6	55.2	56.4	56.6	57.6
			48.7	54.3	55.4	56.9	57.4	57.9
			48.7	54.1	55.5	56.3	57.7	58.0
			48.4	54.0	55.3	56.4	56.7	57.1
Light Red Kidney	29	9.0	33.4	43.9	49.6	51.0	52.9	54.8
		8.9	33.4	43.8	49.3	51.3	53.0	54.9
			33.1	44.5	49.5	51.6	52.6	54.5
			25.0	42.2	47.6	51.3	52.7	55.9
			25.6	38.7	47.3	50.9	52.9	55.1
			25.2	38.0	48.1	51.7	52.4	55.4
Light Red Kidney	57	8.5	35.9	42.6	49.9	51.2	52.0	55.5
		9.2	38.0	42.9	48.7	50.7	52.1	55.9
			37.3	43.5	48.8	50.8	52.7	55.5
			37.9	46.9	49.6	52.5	53.2	54.8
			37.6	46.4	50.6	51.7	52.7	54.8
			39.4	45.8	49.0	51.3	52.8	55.0
Baby Butter	116	5.5	16.4	40.8	46.6	42.5	45.3	57.9
		5.5	16.7	40.0	46.8	42.7	45.1	58.2
			15.9	41.2	46.3	42.6	45.3	58.1
			33.2	38.6	41.8	42.6	49.7	58.1
			32.6	38.3	41.1	42.2	50.0	57.9
			34.2	38.7	41.5	42.3	49.8	57.6

TABLE XX (Continued)

Variety	Lot No.	Soaking Time						
		0 hr.	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	24 hr.
		percent						
Baby Butter	8	3.2	34.9	46.1	49.7	49.4	50.3	57.8
		3.3	34.1	45.9	50.2	49.5	50.2	57.7
			35.1	45.5	49.9	49.9	50.3	57.9
			40.4	42.5	47.6	50.3	50.9	57.1
			40.5	42.8	47.6	49.9	50.8	57.8
			40.3	42.7	48.1	49.9	50.6	57.8

TABLE XXI
CHEMICAL COMPOSITION OF FIVE VARIETIES OF BEAN SKINS

Variety	Pectin	Protein	Fat	Calcium	Moisture
	percent				
Great Northern	72.0	4.22	0.27	35.1	2.37
	79.0	4.32	0.25	35.7	2.45
	84.0	4.25	0.22	34.9	2.26
Navy Bean	86.0	4.44	0.48	44.3	0.50
	88.0	4.53	0.50	44.2	0.77
	90.0	4.66	0.48	44.2	0.60
Black Eye	58.0	8.85	1.17	13.1	3.52
	58.0	9.04	1.16	14.7	3.86
	59.0	9.21	1.26	12.7	3.49
Light Red Kidney	54.0	5.20	0.17	15.6	1.03
	65.0	5.32	0.07	15.1	1.36
	58.0	5.44	0.23	14.9	1.31
Baby Butter	32.0	4.72	0.06	10.09	0.66
	29.0	4.13	0.01	10.60	0.89
	30.0	4.69	0.09	10.78	0.54

VITA

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