COMPOSITIONAL CHANGES OF SELECTED SQUASH CULTIVARS UNDER DIFFERENT STORAGE TEMPERATURE FOR TWO STORAGE PERIODS

by

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INTRODUCTION

Spaghetti squash (Cucurbita pepo) reportedly was introduced from Manchuria (7). It is becoming popular in the United States. The unusual characteristics of this squash is after cooking the flesh can be separated into a mass of strands which resemble spaghetti. The normal crop of squashes in this locality is more than twice the volume than can be consumed by the ultimate consumers before freezing weather arrives. Consequently, a large tonnage of squash is placed annually in storage for use during the winter months (14). Little information is available in the literature on storage and chemical composition of Spaghetti squash. Therefore this study was undertaken to determine some compsitional changes during storage of Spaghetti squash and compared to other winter squash cultivars.

Collins (6) reported on the sensory test of cooked Spaghetti squash and evaluation of the recipes which this squash involved. He reported on the nutritional quality of both frozen and canned Spaghetti squash. Furthermore he stated that Spaghetti squash had excellent storage properties in fresh form and can be stored up to 3 to 4 months. Information on compositional changes of this squash during storage compared to other cultivars has not been reported.

Some important quality criterion for squash are:

(1) Sugars: In studying Blue Hubbard squash edibilty tests substantiated by chemical analyses, Cummings and Stone (9) showed that samples of good quality contain more carbonhydrates and less water than do others of poor quality.

Yeager & Latzke (33) showed a high positive correlation coefficients between total sugars and high quality and total sugar and sweetness in Buttercup squash. The sugar content in squash varies between cultivars and different storage time. Some papers (24, 27) reported that total sugar content increased as storage time increased.

(2) β-carotene: Winter squashes are usually considered an excellent source of β-carotene, provitamin A. Previous studies have shown that squashes contain much more carotene than a large proportion of fruit and vegetables commonly used for human food (14). After evaluating carotene of six cultivars of winter squash during 25 weeks storage, Hopp, Merrow and Elbert (18) stated that the carotene content expresses on a fresh basis increased as storage time increased, but the highest values were obtained in the first 10 weeks of storage, and then remained more or less constant.

(3) Texture: Texture has been considered an important criterion to test quality of fruits and vegetables, especially for stored ones. Textures of squashes not only affects the quality after cooking but influences the storage life of squashes. Kattan and Litterell (19) studied pre- and post-harvest factors affecting firmness in canned sweet potatoes. They found that post-harvest handling had a greater effect on firmness than pre-harvest factors. Storage temperature and duration influenced firmness the most.

(4) Weight loss: Weight loss is an important factor influencing the quality and storage life of stored vegetables and fruits. Much research has been done to determine the optimum atmospheric condition to reduce weight loss as much as possible for stored vegetables and fruits (5, 12). Since weight loss is caused by physiological processes, many researchers of squashes have reported that the percentage of weight loss varies among cultivars, even under

the same atmospheric conditions. The longer the storage time, the more the weight loss (12, 13, 29).

This study was designed to evaluate some characteristics of Spaghetti squash compared to other winter squash cultivars under different storage times and temperatures. The objectives of this study were: (1) compare storage temperature and times for Spaghetti and other winter squash cultivars (2) determine compositional changes under different temperature for both Spaghetti and other cultivars (3) determine compositional changes under different storage times for Spaghetti squash and other cultivars.

LITERATURE REVIEW

The literature reviewed can be grouped into four areas: (1) sugars content and storage, (2) carotene content and storage, (3) firmness and storage, (4) weight loss and storage.

1. Sugar content and storage

One of the first studies on compositional changes of squashes during storage was done by Phillips (27). Three cultivars, Blue Hubbard, Buttercup and Butternut were stored for 3 months (Blue Hubbard for 6 months) and the compositional values were determined during storage. He found the contents of glucose, fructose and sucrose of all three cultivars increased during the 3 months storage, but decreased in storage of 6 months for Blue Hubbard. Fructose was found in excess of glucose in all samples taken at harvest, but the proportion of glucose increased during storage. Phillips also mentioned in his report that Butternut was different from other cultivars. It showed a higher proportion of sucrose in the total sugars. During 3 months of storage glucose content of Blue Hubbard ranged from 9.9% to 25.3%, Buttercup 3.5% to 16.9.%, Butternut 2.2% to 0.6%; fructose content of Blue Hubbard 10.9% to 20.6%, Buttercup 4.8% to 12.0%, Butternut 4.7% to 3.1%; sucrose of Blue Hubbard 3.6% to 10.8%, Buttercup 4.4% to 14.4%, Butternut 8.1% to 39.8% on a dry weight basis.

Merrow and Hopp (24) researched the association between sugar and starch content of six cultivars of winter squashes during 25 weeks' storage. They found that each cultivar had a significantly higher content of sugar after 5 weeks of storage, but with little or no change thereafter. Starch content decreased in an exponential fashion throughout storage. Studies of the storage effect on compositional changes of other fruit and vegetable crops also showed similar results. Phan and Sarkar (26) reported on carrots in storage that the level of total sugars remained almost constant whereas the ration of nonreducing sugars to reducing began to decrease and then remained steady. After 8 weeks of storage nonreducing sugars increased again and reached a maximum between 14 and 18 weeks but then decreased. McCombs, Sox and Lower (23) analyzed sugar contents of several cultivars of cucumber fruits (Cucumis sativus L.) which were harvested and stored for 3 days. They found nearly all of the sugar present was reducing sugar, and storage had little quantitative effect on sugar concentration. High quality in watermelons is largely dependent on high total sugar content. Porter, Bisson and Allinger (28) published that mature watermelon fruits which had been stored at room temperature for two weeks or more had a rapid increase in the ration between sucrose and reducing sugars, and in such fruits sucrose represents 65% of the total sugar.

They also stated sucrose formation proceeds rapidly until fruits are mature. Holmes, Spelman and Wetherbee (15) treated squash vines with maleic hydrazid and expected to reduce sugar loss during storage, but it had no consistent effect on the water, protein or total sugar content of squashes. However, they reported that the total sugars increased from 40.7% to 62.3% during 95 days storage.

Holmes, Smith and Lachman (16) reported that the content of reducing sugars in Blue Hubbard was 3.4%, Buttercup 4.2%, Butternut 0.8%, Des Moines 1.3% and Golden Cushaw 0.5%.

2. Carotene content and storage

The vitamin A value of winter squash shown by Watt and Merriel (32) for the average of three cultivars was 3,700 IU (International units) which included Acorn 1,200 IU, Butternut 5,700 IU, Hubbard 4,300 IU. They also stated that the carotenoid content increased during storage. The amount of increase varied according to cultivar and condition of storage. Holmes, Smith and Lachman (16) determined the carotene compositional value of winter squash. Butternut contained the highest carotene content of five cultivars with 8.5mg/100g fresh weight, Blue Hubbard with 5.5 mg/100g was second, and Des Moines contained the smallest quantity of 0.9 mg/100 g fresh weight nearly 1/10 of Butternut. In another study, Holmes and Spelman (14) analyzed four cultivars of winter squashes for water, carotene, riboflavin, calcium, iron, magnesium and phosphorus, and reported that carotene content was the most striking difference among cultivars. Butternut and Golden Cushaw had higher content on an average of the fresh basis of 7.9 and 7.1 mg/100 g compared to 2.2 mg/100 g in Blue Hubbard.

Six cultivars of winter squashes were harvested and stored for six months by Hopp _et al_ (18), in their research on the effect of storage on β-carotene content of winter squashes. Carotene and total solid were determined at harvest and at 5-week storage intervals. Significant differences were found among the cultivars. The extent of the increase of β-carotene during storage was not consistent with all cultivars, but tended to be the greatest during the first 10 weeks of storage. Holmes _et al_ (15) sprayed Butternut vines with maleic hydrazide in an attempt to slow down metabolic processes and conserve sugar content. However, their results showed no effect of this treatment. They did find an increase in carotene content during 95 days storage. Holmes et al (17) stored Blue Hubbard under light and in the dark. Both groups of squahes showed an increase in β-carotene during the first two months of storage, and then the carotene content decreased. Phan and Sarkar (26) in a carrot storage study found that carotene content increased slightly in the first 12 weeks, but after that decreased slightly.

3. Firmness and storage

Kramer (20) stated that factors of quality included in fruit and vegetables crops are those which the consumer evaluates with his sense of touch. These characteristics are largely determined by mouth feel and include such factors as tenderness or hardness, chewiness, juiciness, grittiness and fibrousness. In general, these factors are objectively measured by mechanical instruments. Kramer described these characteristics of vegetables and used the terms of "texture, mealiness, fiber." Mechanical instrument he suggested to measure the texture of vegetables were tenderometers, texture meters, compressing, penetrating, cutting instruments etc. In addition to these, textural characteristics of some products can be measured by chemical means for examples, fiber, pectin, cellulose etc. (10).

Phillips (27) determined the compositional change of three cultivars: Blue Hubbard, Buttercup and Butternut during storage and found that in percentage of dry weight, both cellulose and pectin increased almost 2-fold after 3 months storage. Phillips mentioned these increases possibly were relative rather than absolute. Kattan and Litterell (19) studied the pre- and post-harvest factors which effect firmness of canned sweet potatoes. They stated that post-harvest handling had much greater effect on firmness of canned sweet potatoes. Raw sweet potatoes were stored at room temperature or cured at 85°F and then stored at 60°F. These sweet potatoes were then canned and firmness of the canned product decreased progessively with storage duration. This was associated with rapid decrease in alcohol insoluble solids (A.I.S.) and starch. In contrast, when stored at 35°F, firmness of the canned products continued to increase, and was associated with increase in AIS and starch of the canned product. Smittle and Hayes (30) stored 'Dixie Hybrid' squash at 5, 10 and 15°C for 9 days and related storage temperature to texture evaluation of the cooked product. They reported that chemical changes during storage at high temperature consisted of increase in water-soluble pectin, pectin, sodium hexametaphosphate-soluble pectin, cellulose and decrease in starch and protopectin.

4. Losses during storage

Losses of squashes during storage are important economic factors and may be considered as tow parts: weight loss and decay loss. The storage conditions relating to these two factors is somewhat complicated, because high humidity and low temperature reduces weight loss of squash fruits, but increases decay loss. Conversely, low humidity and high temperature causes a high percent of weight loss but low decay (12). Francis and Thomson (12) tried to find optimum storage conditions for Butternut squash with regard for losses due to decay and weight loss. They stored squashes at temperature from 45-70°F and 60-70% relative humidity. Medium temperature and low humidity markedly decreased decay but increased weight losses and hollow-neck development. They suggested that decay was much more important than weight loss and conditions should have been chosen to minimize decay, weight loss and hollow-neck development was to be stored at 55°F and 55% R. H. Holmes et al (17) stored squash at 15 to 20°C and 30-40% of R.H. for 9 weeks. The total weight losses of storage in dark was 20.3% and light was 15.8%. While the total decay losses during 9-week storage was 69.9% for dark and 77.9% for light. Schales et al (29) investigated the effects on storage of winter squash.

They used 50-60°F and 30 to 90% R.H. for common storage (control). The cured squashes were held at 80°F for 3 weeks before they were placed in common storage. They found that losses from decay were about the same for the cured and un-cured fruits although cured fruits decayed more rapidly. Over the entire storage period decay losses were 15 to 20% for Butternut and 5 to 10% for Blue Hubbard and Quality, while Acorn was effected most by curing at high temperature. Smittle and Hayes (30) studied the post-harvest quality changes of summer squashes. They found that during 9 days at 5, 10 and 15°C storage, weight loss was four times more at 10°C and six times greater at 15°C than at 5°C storage when relative humidity was 85 to 95%.

MATERIALS AND METHODS

The cultivars of winter squashes used in this experiment were: Spaghetti (*Cucurbita pepo*) (6), Acorn (*C. pepo*), Butternut (*C. moschata*), and Golden Hubbard (*C. maxima*) (21). All squashes of these four cultivars were grown and harvested at Ashland Horticultural Farm of Kansas State University, Manhattan, Kansas. The squashes were cured at room temperature for one month before they were stored.

All squashes of each cultivar were divided into three lots, the first one was treated as cured, the other two lots were stored at either 13°C (with 95% R.H.) or 21°C (with 70% R.H.) storage rooms. Storage periods for 1 month and 2 months were evaluated. Each treatment included all four cultivars with four replications of one fruit each.

Weight loss:

All samples were weighed before storage and after 1 month and 2 months of storage. The percentage of weight loss during storage was calculated and the percentage of decay observed.

Texture test:

All samples were tested by using a pressure tester on both the rind (punched rind from outside through inside) and the flesh (punched flesh from inside) with Magness-Taylor pressure tester (0.4 cm diameter). Each fruit was tested randomly at 3 locations for both rind and flesh to get an average reading for each pressure test.

Preparing for determination of sugars and β-carotene:

After texture test, each squash was peeled, the middle part of each fruit was sampled. Samples of each squash were mixed and divided as follows: 25g for sugars determination and 50 g for β-carotene. The samples were placed in covered bottles and frozen at $-10^{\circ}C$ to stay over night, if the analysis could not be done immediately after sampling.

The determination of sugars and β-carotene for raw fruit were treated as the sames as others, except for weight loss and texture test.

Sugar Determination:

The method used for sugar determination followed the procedure of Ting (31).

A. Extraction of the sugars:

1. The squashes were peeled and a 25 g flesh sample was used for chemical analysis of each fruit.
2. Sugar was extracted by blending the 25 g sample with 100 ml of 95% ethanol in Sorvall Omni-Mixer for two minutes.
3. The mixture was filtered through filter paper in a Buchner funnel with suction for 2-3 minutes.
4. The extract was diluted to 500 ml with 75% ethanol.

B. Preparing of solution for sugar analysis:

1. Twenty five ml of squash extract solution was transfered to a 250 ml beaker.
2. The beaker of squash extract sugar solution, which contained approximately 80% alcohol was placed on a hot plate under a hood in order to evaporate the alcohol to a small volume (about 3-5 ml). The extract was heated for about 30 minutes.

3. About 25 ml of water was added to wash the residue, and heating was continued for 5-10 minutes or until most of the alcohol was evaporated.

4. After evaporation of alcohol, the solution was transfered to a 250 ml volumetric flask, and brought to a volume with distilled water to form solution A.

C. Total sugar determination:

1. Fifty ml of solution A were placed in a 250 ml beaker and 10 ml of HCl 1:1 were added. The beaker was allowed to stand overnight to hydrolyze the sucrose to glucose and fructose.
2. After 18 hours at room temperature, 5 ml of 10 N NaOH (40%) were added and the content adjusted to pH 7 with 1 N NaOH solution using a pH meter.
3. The contents were then transfered to a 100 ml volumetric flask and diluted to volume with distilled water.
4. Two ml aliquot of this solution was pipetted into a 100 ml volumetric flask and 5 ml of alkaline ferricyanide reagent was added.
5. The flasks were immersed in a boiling water bath for 10 minutes.
6. After heating the flasks, they were rapidly cooled in running water, and the contents were rapidly neutralized with 10 ml of 2 N H_2SO_4 solution.
7. The contents of the flask were mixed until no more gas evolved.
8. Four ml of the arsenomolybdate solution were added.
9. The contents of the flasks were again mixed and diluted to 100 ml, and allowed to stand 30 to 60 minutes. The

ferrocyanide-arsenomolybdate complex becomes stable about 15 minutes after its preparation, but after 1 hour the absorbance decreases gradually. Therefore, all measurement had to be taken 30 to 60 minutes after the formation of the complex.

10. A blank was treated in exactly the same way as the sample.
11. The solutions were read with the Beckman Spectrophotometer and the absorbances were measured at 745 nm.
12. The absorbances were compared with a standard curve.

D. <u>Reducing sugar determination</u>:

1. A 5 ml aliquot of solution A was transfered to a 100 ml volumetric flask.
2. Five ml of alkaline ferricyanide reagent were added.
3. The flasks containing the above solution were immersed in a boling water bath for 10 minutes.
4. After heating, the flasks were cooled quickly in running water.
5. Ten ml of 2 N H_2SO_4 were added to partially neutralize the solution.
6. The contents of the flasks were thoroughly mixed until no more gas evolved.
7. Four ml of arsenomolybdate were then added.
8. The resulting solution was mixed again and diluted with distilled water to 100 ml.
9. The flasks were allowed to stand 30 to 60 minutes.
10. A blank was treated in exactly the same way as the sample.
11. The solutions were read with Beckman Spectrophotometer and the absorbances were measured at 745 nm.
12. The absorbances were compared with a standard curve.

E. Fructose determination:

1. Ten ml of solution A were transfered into a 100 ml volumetric flask.
2. Five ml of alkaline ferricyanide reagent were added.
3. The flasks containing the above solution were immersed for 30 minutes in a water bath which had a constant temperature of 55°C.
4. After heating, the flasks were rapidly cooled in running water.
5. Ten ml of 2 N H_2SO_4 were added in order to partially neutralize the solution.
6. The contents of the flasks were thoroughly mixed until no more gas evolved.
7. Four ml of arsenomolybdate were added.
8. The resulting solution was mixed again and diluted with distilled water to 100 ml.
9. The solution was allowed to stand for 30 to 60 minutes.
10. A blank was treated in exactly the same way as the sample.
11. The colored solution was placed in the Beckman Spectrophotometer and the absorbance measurement was made at 745 nm.
12. The absorbances were compared with the standard curve.

The reagents used in this study are listed in the appendix, as is the standard curve for sugar determination.

G. Calculation:

1. Total sugar:

The color of the solution after the addition of the arsenomolybdate was studied by means of Beckman Spectrophotometer at 745 nm, using a 1 cm cell. The reading obtained (absorbance) was placed on the standard curve. Then an imaginary line was drawn down to the abscissa and the value was noted. This was multiplied by a dilution factor of 20,000 for total sugar.

2. Fructose and Glucose:

The percentage of apparent fructose was calculated by placing the absorbance value obtained from the sample on the standard curve. Then a line was drawn down to the abscissa. The value obtained was multiplied by a dilution factor of 2,000 to get the percent of apparent fructose.

Glucose was calculated by substracting the concentration at 55°C (apparent fructose) from the concentration at 100°C (reducing sugar), then dividing by 0.88.

$$\text{Glucose} = \frac{C_{100} - C_{55}}{0.88}$$

Fructose then was calculated by substracting glucose from reducing sugar:

Fructose = Reducing sugar - Glucose

3. Reducing sugar:

Calculated by placing the absorbance value obtained on the standard curve. The value obtained where the line crossed the abscissa was multiplied by a dilution factor of 4,000.

4. Sucrose:

Calculated by substracting reducing sugar from total sugar, then multiplied by 0.95

Sucrose = (Total sugar - Reducing sugar) x 0.95

β-carotene determination:

Analyses were made for β-carotene using a modified AOAC (2) method by increasing sample size to 50 grams and alcohol volumes 5 fold for extraction with blending. Instead of using 10% acetone in hexane (skellysolve), 4% acetone in skellysolve B was used to slow down elution of carotene.

A. Preparation of sample:

1. Fifty grams of squash were weighed and put into a blender cup.
2. Sixty ml of skellysolve B and 200 ml of 95% ethyalcohol was added. The purpose of alcohol was to dehydrate the tissues to allow skellysolve B to penetrate the cells and extract carotene.
3. The mixture was blended for approximately 5 minutes at high speed with a Waring Blender.
4. The slurry was filtered through filter paper in a Buchner funnel with suction, and residue was washed with approximately 50 ml of skellysolve B.
5. The filtrate was transferred to a 500 ml separatory funnel.

Then 100 ml of water containing about 1 gram of sodium sulfate was added. Sodium sulfate was used to prevent emulsions.

6. The mixture was allowed to stand a few seconds and the water-alcohol layer was drawn off.
7. The water-alcohol layer was extracted twice more with 50 ml portions of skellysolve B.
8. All of the skellysolve B extracts were combined and washed twice with water to eliminate the alcohol.

B. Separation and determination of β-carotene:

1. The washed extract was transferred to a 600 ml beaker and concentrated on a hot plate to about 30 ml.
2. A column was prepared by placing a small cotton plug inside the chromatographic tube, then loose adsorben (MgO-supercel 1:1) was added to 10-15 cm depth. The tube was attached to suction flask, and full vacuum of water pump was applied. Tamping rod was used to gently press adsorbent and flatten surface (packed column had to be about 10 cm deep). A 1 cm layer of anhydrous sodium sulfate was placed above adsorbent.
3. The concentrated extract was chromatographed on a column of MgO-supercel 1:1. Supercel was used to make the mixture porous enough for β-carotene to elute through activated MgO which was used as an adsorbent.
4. After all extract was attached to adsorbent, the carotene was eluted using a solution of 4% acetone in skellysolve B.
5. The eluate was collected in a 250 ml volumetric flask, diluted to volume with skellysolve B.

6. The color intensity was measured photometrically at 436 nm with a Beckman Spectrophotometer.
7. The blank was made with double distilled water.

C. Calculation:

Two fundamental laws are associated with Spectrophotometry; these are Lambert's and Beer's laws. By combining both laws we obtain:

$$A = \log_{10} \frac{I_0}{I} = \alpha \cdot 1 \cdot c$$

A : absorbance

I_0: incident light intensity

α : absorbancy index characteristic for the solution

1 : length or thickness of the medium

c : concentration of solute (carotene) in solution

If 1 is held constant by employing a standard cell or cuvette, the Beer-Lambert law reduces to:

$$A = \log_{10}\frac{I_0}{I} = \alpha c$$

Since value of A was known and α= 196 for β-carotene, the concentration was calculated

$$c = \frac{A}{\alpha} = \frac{A}{196} = \text{grams of carotene/liter of solution}$$

This was multiplied by a factor of 500 to get concentration of β-carotene in mg/100 grams fresh weight of squash.

Statistical analysis:

Analysis of variance was performed on all data using the SAS computer program. The least signigicant difference (L.S.D.) multiple comparison was performed, too.

RESULTS AND DISCUSSION

Four cultivars of winter squash: Spaghetti, Acorn, Butternut, and Golden Hubbard were stored at either 13°C or 21°C for 1 month and 2 months. All four cultivars were sampled for sugars (including glucose, fructose and sucrose), β-carotene, percentage of weight loss determination and texture test (both rind and flesh test). The results are presented in Table 1 and Table 2.

1. <u>Percentage of weight loss</u>:

When stored at 13°C, Spaghetti squash had 3.1% weight loss for storage 1 month and 5.7% for 2 months. There were no significant difference in weight loss between these two periods of storage time for all four cultivars. There was no significant difference among cultivars for weight loss at either 1 month or 2 months at 13°C storage.

At 21°C, Spaghetti squash had higher percentage of weight loss with 6.7% for 1 month and 7.3% for 2 months than at 13°C, although this was not a statistical comparison. It is evident that weight loss was less at 13°C. Significant difference of weight loss at 21°C between 1 month and 2 months storage for all four cultivars did not occur, either. However, for both 1 month and 2 months storage, Spaghetti showed lower percentage of weight loss than Acorn which had the highest percentage of weight loss among four cultivars with 21.7% and 22.2% of weight loss at 21°C storage (Table 2).

There was more weight loss at 21°C during 2 months storage than at 13°C especially for Acorn, Butternut and Golden Hubbard, although this is not a statistical comparison, because we did not have replicated storage rooms.

The percentage of weight loss in this study are higher than those of Olorunda et al's (25). They found 2.9% of weight loss of Acorn when stored at 20°C, and 2.0% at 10°C for 4 weeks storage. Holmes (13) found 20.3% of weight loss of Butternut at 15-20°C and 30-40% of R.H. for storage of 9 weeks. In this study weight loss was 6.6% at 13°C and 12.3% at 21°C for Butternut squash after 2 months storage. The lower weight loss in this study compared to Holmes' was probably due to higher relative humidity in this study.

Weight loss during storage is caused by respiration, transpiration and other metabolic processes. Higher temperature normaly increases the respiration rate of squash fruit. Low relative humidity results in increased transpiration rate. Both of them cause weight loss of squashes. This can explain the reasons why there were lower percentage of weight loss at 13°C (95% R.H.) than those at 21°C (70% R.H.). This agree with Francis et al (12).

Spaghetti squash had a lower weight loss, although it was not significantly different at 13°C storage, when compared to other cultivars. This may suggest that Spaghetti squash has potential for long period of storage (Fig. 1).

2. Sugars:

Two very important reducing sugars, fructose and glucose and one non-reducing sugar, sucrose, were determined.

(1) Fructose

Fructose content of these four cultivare of winter squashes used in this experiment were similar, except the lower value in Butternut squash. The amount of fructose of Spaghetti squash was 0.87 g per 100 g of fresh weight as cured, and remained at 0.87 g for 1 month, then a significant increase occured in 2 months with 1.42 g at 13°C storage. The fructose content of Spaghetti for storage 1 month at 21°C was very close to the one at 13°C but had a lower content in 2 months when compared to that at 13°C. Acorn and Golden Hubbard had about the same value as Spaghetti, with 1.06 g to 1.47 g and 0.80 g to 1.25 g per 100 g of fresh weight, respectively. The content in Butternut was with a lower value of 0.27 g to 0.61 g (Table 1).

As a cured fruit, Acorn had the highest content of fructose, Spaghetti and Golden Hubbard were second, and Butternut had the lowest content of fructose. After 1 and 2 months of storage, there was no difference among Spaghetti, Acorn and Golden Hubbard. Butternut fruits still contained the lowest content of fructose among the four cultivars. The same situation occured at 21°C storage (Table 1).

Spaghetti squashes had a significant increase in fructose content after 2 months storage at 13°C. Fructose content in Acorn squash decreased after 1 month of storage but increased after 2 months at 13°C. Both Butternut and Golden Hubbard were not significantly different in fructose after 2 months storage at 13°C. Fructose content of these four cultivars was not influenced by storage time when stored at 21°C temperature. Spaghetti, Acorn and Golden Hubbard had similar fructose content around 0.87 g to 1.47 g per 100 g fresh weight, and Butternut contained the lowest fructose content. The fructose content of Spaghetti increased after 2 months at

13^{o}C, but did not have so evident effect at 21^{o}C. Butternut and Golden Hubbard fructose content were similar at both 13^{o}C and 21^{o}C during 2 months storage, while Acorn had a significant decrease after 1 month storage at 13^{o}C. The data showed that there were higher fructose contents at 13^{o}C than those stored at 21^{o}C even though it was impossible to use statistical analysis (Fig. 2).

The trend of furctose content during 2 months storage was not as consistent as the data in Phillip's (27) rport. He found the fructose content of Blue Hubbard and Buttercup gradually increased, and Butternut decreased during 3 months storage. The fructose content of Butternut squash in Phillip's study is similar to those in this study.

(2) Glucose

Glucose content in winter squash was higher than fructose content. The glucose contents by cultivars in descending order were Hubbard, Acorn, Spaghetti and Butternut (Table 1). The trend of glucose content during storage, showed that only Spaghetti and Golden Hubbard decreased significantly at 13^{o}C after 2 months storage. Acorn and Butternut showed no significant changes of glucose content during 2 months storage at 13^{o}C.

A non-statistical comparison of glucose content of winter squash under 13^{o}C and 21^{o}C storage indicates that Golden Gubbard fruits were higher at 13^{o}C than those at 21^{o}C; whereas both Acorn and Butternut had a higher glucose content at 21^{o}C than those at 13^{o}C during 2 months storage. Spaghetti had higher glucose content for 1 month but lower for 2 months at 13^{o}C when compared to 21^{o}C storage.

Thus glucose content in Spaghetti squash was lower than Golden Hubbard and Acorn, but was much higher than Butternut (Fig. 3). Storage time influenced the content of glucose in Spaghetti squash. There was a significant decrease in glucose for fruits stored at 13°C from 1 months to 2 months storage. Glucose decreased in Golden Hubbard fruits during storage but the glucose content remained the same during 2 months storage for Acorn and Butternut cultivars.

The only reference which determined the glucose content of winter squashes was Phillips' (27). He found both Blue Hubbard and Buttercup increased in glucose content during 3 months storage. He also stored Blue Hubbard squash up to 6 months and glucose content decreased after 6 months storage. In contrast, Butternut squash significantly decreased during storage of 3 months. In this study, only Spaghetti and Golden Hubbard had significant decrease at 13°C after 2 months storage. The glucose content of Butternut determined in his study is consistent with the results in this study.

(3) Sucrose

Sucrose content was much higher than the reducing sugars, fructose and glucose, in these four cultivars of winter squashes. No reference was found on sucrose content of Spaghetti squash. In this study it contained 3.72 g of per 100 g fresh weight as cured and 1.34 g after 1 month storage and 1.89 g in 2 months at 13°C, and 2.43 g in 1 month, 2.28 g in 2 months at 21°C storage. Golden Hubbard contained similar amounts of Spaghetti, 2.12 g to 3.91 g per 100 g fresh weight. The content of sucrose was higher in Acorn, with amounts of 3.08 g to 6.41 g. Butternut contained the highest sucrose among the four cultivars, from 6.80 g to 10.33 g per 100 g fresh weight (Table 1).

The sucrose contents changed variously with storage time. Under 13°C temperature, there was not significant effects of storage time on sucrose content of Spaghetti and Golden Hubbard, which had the lowest sucrose content among the four cultivars. Butternut had a significant increase after 1 month storage, while Acorn increased after 2 months at 13°C. There were no effects of storage times on sucrose content of Spaghetti, Acorn and Golden Hubbard at 21°C, but Butternut had a significant increase in sucrose content after 1 month.

The effects of temperature on sucrose content indicated that Spaghetti squash had higher sucrose content at 21°C than those at 13°C for both storage of 1 month and 2 months. Acorn contained a higher sucrose content at 13°C than at 21°C. The sucrose content of Butternut and Golden Hubbard were lower after 1 month and higher after 2 months at 13°C storage as compared to those at 21°C.

To conclude, Spaghetti was similar to Golden Hubbard for sucrose content. The Spaghetti cultivar contained the lowest sucrose content, while, Butternut contained the highest sucrose content among the four cultivars (Fig. 4). The sucrose contents of Spaghetti and Golden Hubbard were not significantly different after 2 months storage. The sucrose content increased significantly after 2 months storage of Acorn and Butternut.

Three cultivars: Blue Hubbard, Buttercup and Butternut were analyzed for sucrose content in Phillips' (27) study. He showed an increase in sucrose content during 3 months storage (sucrose decreased after 6 months storage of Blue Hubbard). Especially for Butternut, it increased almost 3-fold in 3 months after harvest. Butternut and Acorn significantly increased here after 1 month and 2 months storage, respectively. The sucrose content of Butternut squash in this study was much higher than those in Phillips' research about 2-fold after 2 months storage.

Conclusion of sugars:

The three sugars, fructose, glucose and sucrose in these four cultivars of winter squashes ranked the same: the highest content of sucrose, then glucose, and the lowest level of fructose. The non-reducing sugars, fructose and glucose, appeared in Spaghetti squash at about the same levels as Acorn and Golden Hubbard. Spaghetti contained the lowest content of sucrose but it was not significantly different from Golden Hubbard. Butternut squash contained the lowest content of glucose and fructose, but the highest level of sucrose. This indicates various ratios of reducing and non-reducing sugars in witner squash cultivars.

The determinations of sucrose, glucose and fructose content for each cultivar indicated glucose content in excess of fructose, except for cured Butternut squash and those stored at 13°C for 2 months. In a biochemical study of the development of cucurbit fruits, Arasimovich (3) reported that glucose content is always in excess of fructose. Phillips (27) analyzed Blue Hubbard, Buttercup and Butternut and found that fructose was in excess of glucose in all samples taken at harvest. Sucrose content was always higher than glucose and fructose for all cultivars in this study. According to Phillips' report sucrose content of Blue Hubbard was lower than fructose and glucose. Porter, Bisson and Allinger (28) also found that mature watermelon which was stored for two weeks or more had higher sucrose content than reducing sugars with 65% of the total sugars. Both fructose and glucose contents increased in Phillips' study during 3 months storage. Whereas, Spaghetti and Golden Hubbard decreased in glucose after storage of 2 months. In a study of the relationship of sugars and starch content during storage, Merrow and Hopp (24) stated that there was significantly higher content of sugar after 5 weeks of storage, and the major decrease of 60% of starch occured during the first 10 weeks. In the future analysis of the starch content of Spaghetti squash would be desirable to obtain additional information about the changes of carbonhydrates during storage of this new cultivar of winter squash.

3. β-carotene

The β-carotene content of winter squashes is variable among cultivars (Table 2). The range of β-carotene content of these four cultivars were from 0.07 mg per 100 g fresh weight to 10.27 mg. The β-carotene values of Spaghetti squash in this study were very small, especially when compared to the Butternut cultivar. The β-carotene of cured Spaghetti was 0.19, and 0.07 mg for storage 1 month at 13°C and then 0.13 mg for 2 months. The values for those stored at 21°C were 0.10 mg for 1 month and 0.16 mg for 2 months. The β-carotene content of Acorn and Spaghetti squash was similar in each storage period, with 0.21 to 0.82 mg per 100 g fresh weight. Golden Hubbard was the next highest in β-carotene content ranging from 1.49 mg to 3.85 mg. Butternut squash contained β-carotene 6.53 mg to 10.27 mg per 100 g fresh weight (Table 2), which was about seventy times the value of Spaghetti and it was significantly higher.

The β-carotene content of Spaghetti, Acorn and Golden Hubbard showed no significant increase at 13°C during 2 months storage. Butternut β-carotene increased significantly after 1 month, and retained the amount for 2 months. There was no difference of β-carotene content of the squash cultivars due to storage at 21°C for 2 months.

In a non-statistical comparison of two temperature on β-carotene content, Butternut squash had lower contents at 21°C than at 13°C for 1 month and 2 months storage. However, Spaghetti and Acorn had a higher β-carotene at 21°C than those stored at 13°C. Golden Hubbard varied in β-carotene content. It had a higher value in 1 month and lower in 2 months at 13°C temperature when compared to 21°C storage.

The β-carotene content of Spaghetti squash was not significantly different from Acorn. The β-carotene content of Butternut was the highest about 70 times higher than Spaghetti. The changes of β-carotene content during storage were not significant for Spaghetti, Acorn or Golden Hubbard. However, Butternut squash increased significantly after 1 month storage at 13°C (Fig. 5).

Winter squashes have been considered a very good source of β-carotene. Holmes and Spelman (14) stated that Blue Hubbard and Delicous squashes contained much more carotene than was found in a large proportion of the fruits and vegetables commonly used. But from the data presented here, Spaghetti squash won't be consumed as a good source of β-carotene, provitamin A.

The β-carotene content of Butternut squash as determined by Holmes and Spelman (14) was about 7.94 mg/100 g fresh weight; Holmes, Smith and Lachman (16) also reported that Butternut squash had β-carotene content average 8.5 mg/100 g freash weight. My research results agree with those authors. However, there was a lower β-carotene content of Butternut squash with 1.0-1.8 mg/100 g fresh weight in Hopp, Merrow and Elber's report (18). In their storage study of six varieties of winter squashes for 6 months, they also found that β-carotene on a freash basis tended to increase during the first 10 weeks of storage, and then it remained more or less constant. There was no significant increase in β-carotene content of Acorn, Spaghetti and Golden Hubbard squashes during 2 months storage. However, Butternut squash significantly increased in β-carotene after 1 month storage at 13°C. Fitzgerald and Fellers (11) determined the carotene content of fresh market vegetables, and reported that pumpkin and squashes had β-carotene content in the range of 1.1-12.0 mg/100g. From this study here, Spaghetti and Acorn squashes seemed much less than the average range. Holmes, Spelman and Wetherbee (15) reported 18.6 mg of β-carotene at harvest and 30% increase to 24.2 mg/100 g fresh weight for Butternut cultivar after 95 days storage.

4. Texture test

This test was performed after 1 month and 2 months storage.

(1) Rind:

The hardness of rind of winter squashes in this experiment was determined by a pressure tester. The pressure for testing the rind of Spaghetti was 1.60 kg/cm^2 for 1 month and 1.78 kg/cm^2 for 2 months at 13°C storage, and 1.41 kg/cm^2 for 1 month, 1.65 kg/cm^2 for 2 months at 21°C. Spaghetti squash rinds were not as hard as Acorn and Butternut. Both of them required pressure of 1.82 to 2.00 kg/cm^2 to puncture the rind. Golden Hubbard was softer than the other three cultivars with pressure of 1.08 to 1.27 kg/cm^2 puncture the fruit (Table 2). The effects of storage time on the hardness of rind of all four cultivars were not significant at either 13°C or 21°C.

The hardness test of rind for those stored at 13°C always appeared higher than those stored at 21°C, except Butternut in 2 months storage. But this was not analyzed by statisctical methods.

Acorn and Butternut were the hardes for rind pressure test among the four cultivars, Spaghetti was softer than those two, and Golden Hubbard was much softer than the other three cultivars (Fig. 6).

(2) Flesh:

The pressure tests for flesh of these squashes were lower than those for rind. The reading of flesh test for Spaghetti squash under 13°C storage were 1.06 kg/cm^2 for 1 month, 1.25 kg/cm^2 for 2 months; and 1.02 kg/cm^2 for 1 month, 1.20 kg/cm^2 for 2 months under 21°C condition. Golden Hubbard was similar to Spaghetti with pressure tests of 1.13 to 1.18 kg/cm^2. The firmness of flesh between Spaghetti and Golden Hubbard was not significantly different during 2 months storage. Acorn and Butternut fruits were harder than Spaghetti and Golden Hubbard, with reading of 1.28 to 1.48 kg/cm^2 and 1.34 to 1.56 kg/cm^2, repectively (Table 2).

There were significant increases in firmness of flesh of Spaghetti from 1 month to 2 months at both 13°C and 21°C storage. Flesh texture was not effected either at 13°C or 21°C or 1 or 2 months storage for Acorn, Butternut or Golden Hubbard cultivars.

Spaghetti squash stored at 13°C had firmer flesh than those stored at 21°C. The opposite condition occured for Acorn and Butternut cultivars. Golden Hubbard fruits were similar in flesh test after both 1 and 2 months storage.

Conclusion for the flesh test, the flesh of Spaghetti squash was softer than Acorn and Butternut, but similar to Golden Hubbard (Fig. 7). Storage times used did affect the firmness of flesh of Spaghetti. The lower storage temperature used resulted in firmer flesh for Spaghetti squash, however, this is not a statistical comparison.

Both flesh and rind pressure test of Golden Hubbard was softer than the other three cultivars in this study. In analyzing different stages of development and different periods of storage of thirty-six varieties of pumpkin and winter squashes, Culpeper (8) reported that Golden Hubbard was thicker or heavier consistency than Table Queen (Acorn).

As mentioned earlier, Kattan and Littrell (19) studied pre- and post-harvest factors which affect firmness of canned sweet potatoes. They found when raw sweet potatoes were stored at room temperature or when cured at 85°F and stored at 60°F firmness of the canned products decreased progressively during storage. When raw sweet potatoes were stored at 35°F, firmness of the canned product continued to increase. Storage temperature of the raw product is a factor that influences the firmness of canned sweet potatoes. It was found both at 13°C and 21°C temperature, the trends of pressure test values for Spaghetti squash were similar during two months of storage.

Introducing some objective measurements of texture, Arthey (4) mentioned that the disadvantages of Magness-Taylor pressure tester are that different operators may obtain different results when testing similar fruits. More accurate instruments may be needed to test the texture of winter squash cultivars.

5. Deterioration

The deterioration of these squashes were observed, but was not analyzed by statistical methods. Acorn and Golden Hubbard were more susceptible to decay. Twenty five percent of Acorn squashes decayed at both 13°C and 21°C condition after being stored 1 month and increased to 37% rot at 21°C after 2 months storage. Thirty seven percent of Golden Hubbard squashes decayed at 21°C after 1 month storage, but this percentage did not change after 2 months storage. Golden Hubbard kept much better at 13°C than at 21°C. Butternut squash did not decay, but some fruits were shriveled after 2 months storage. There was not any deterioration of Spaghetti squash under either 13°C or 21°C temperature during 2 months storage.

Lutz and Hardenburg (22) suggested to store winter squash at 10-21°C and 50-70% R.H.. This study indicates that temperature from 13°C to 21°C relative humidity from 70 to 95% are satisfactory for storage of Spaghetti squash.

Spaghetti squashes had the best storage quality among these four cultivars during 2 months storage. Its fruits did not decay, nor did they shrivel. As mentioned earlier, Spaghetti also lost the least percentage of weight during storage. These properties indicate good characteristics of Spaghetti squash for storage.

Table 1. The effect of storage temperature and time on the fructose, glucose and sucrose content of four winter squash cultivars.

Temperature and cultivar		Fructose g/100 g			Glucose g/100 g			Sucrose g/100 g		
		cured	1 mo.	2 mo.	cured	1 mo.	2 mo.	cured	1 mo.	1 mo.
13°C:	Spaghetti	0.87 ab[z]	0.87 a	1.42 e	1.58 a	2.06 ad	0.99 e	3.72 a	1.34 a	1.89 a
	Acorn	1.46 c	1.06 a	1.47[x] ec	1.84 a	1.94 a	1.85[x] a	3.08 ae	5.37 de	6.41[x] d
	Butternut	0.61 ad	0.40 d	0.41 d	0.41 b	0.44 b	0.32 b	6.80 b	9.48 c	10.33 c
	Golden Hubbard	1.01 be	0.91 ae	1.25 e	2.53 c	2.59 dc	1.93 a	3.91 a	2.12 a	2.68 a
	L. S. D.	$LSD_{.05}(4,4)^w = 0.36$			$LSD_{.05}(4,4) = 0.55$			$LSD_{.05}(4,4) = 2.53$		
		$LSD_{.05}(4,3) = 0.39$			$LSD_{.05}(4,3) = 0.60$			$LSD_{.05}(4,3) = 2.73$		
21°C:	Spaghetti	0.87 a	0.86 a	0.97 a	1.58 a	1.52 ac	1.19 a	3.72 a	2.43 a	2.28 a
	Acorn	1.46 b	1.07 ab	1.32 ab	1.84 ad	2.23 d	1.87 d	3.08 ac	4.73 c	5.18 c
	Butternut	0.61 ac	0.27 c	0.35 c	0.41 b	0.90 b	0.67 ab	6.80 b	10.16 d	9.01 d
	Golden Hubbard	1.01 a	0.80 a	1.03[y] a	2.53 c	2.02 cd	1.89[y] dc	3.91 a	2.36 a	2.51[y] a
	L. S. D.	$LSD_{.05}(4,4) = 0.43$			$LSD_{.05}(4,4) = 0.61$			$LSD_{.05}(4,4) = 2.17$		
		$LSD_{.05}(4,2) = 0.52$			$LSD_{.05}(4,2) = 0.75$			$LSD_{.05}(4,2) = 2.65$		

x means derived from 3 replications and y means derived from 2 replications, the others are 4 replications.
w the numbers of replications with the two pair-wise means.
z the same letter in rows and column indicates no significant difference between means.

Table 2. The effect of storage temperature and time on percentage of weight loss, carotene content and texture of the rind and flesh of winter squash cultivars.

Temperature and cultivar	Loss of weight %		β-carotene mg/100g			Pressure test value kg/cm²			
						Rind		Flesh	
	1 mo.	2 mo.	cured	1 mo.	2 mo.	1 mo.	2 mo.	1 mo.	2 mo.
13°C: Spaghetti	3.1 a[z]	5.7 a	0.19 a	0.07 a	0.13 a	1.60 bd	1.78 ad	1.06 a	1.25 cd
Acorn	8.6 a	14.0 a	0.21[x] a	0.22 a	0.54[x] a	1.91 a	1.89[x] a	1.28 bc	1.37[x] c
Butternut	5.1 a	6.6 a	6.53 b	10.03 c	10.27 c	1.94 a	1.98 a	1.37 c	1.34 c
Golden Hubbard	4.7 a	12.1 a	1.49 ad	3.54 d	2.99 ad	1.27 c	1.22 c	1.16 ab	1.13 ad
L. S. D.	NS		$LSD_{.05}(4,4)^{w}$ = 3.10 $LSD_{.05}(3.3)$ = 3.57 $LSD_{.05}(4,3)$ = 3.34			$LSD_{.05}(4,4)$ = 0.23 $LSD_{.05}(4,3)$ = 0.30		$LSD_{.05}(4,4)$= 0.18 $LSD_{.05}(4,3)$= 0.19	
21°C: Spaghetti	6.7 a	7.3 a	0.19 a	0.10 a	0.16 a	1.41 b	1.65 b	1.02 a	1.20 c
Acorn	21.7 b	22.2 b	0.21[x] a	0.82 a	0.79 ac	1.82 a	1.84 ab	1.48 b	1.43 b
Butternut	15.3 ab	12.3 ab	6.53 b	8.74 b	8.80 b	1.83 a	2.00 a	1.46 b	1.56 b
Golden Hubbard	15.9 ab	11.3[y] ab	1.49 ac	2.48 ac	3.85[y] c	1.08 c	1.13[y] c	1.16 ac	1.18[y] c
L. S. D.	$LSD_{.05}(4,4)$=13.1 $LSD_{.05}(4,2)$=16.1		$LSD_{.05}(4,4($ = 2.70 $LSD_{.05}(4,3)$ = 2.92 $LSD_{.05}(4,2)$ = 3.31			$LSD_{.05}(4,4)$ = 0.31 $LSD_{.05}(4,2)$ = 0.38		$LSD_{.05}(4,4)$= 0.15 $LSD_{.05}(4,2)$= 0.19	

x means derived rom 3 replications and y means derived from 2 replications, the others are 4 replications.
w the numbers of replications with the two pair-weise means.
z the same letter in rows and column indicates no significant difference between means.

THIS BOOK CONTAINS NUMEROUS PAGES THAT WERE BOUND WITHOUT PAGE NUMBERS.

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Fig. 1. Percent of weight loss of squash cultivars stored 1 or 2 months at 13°C or 21°C.

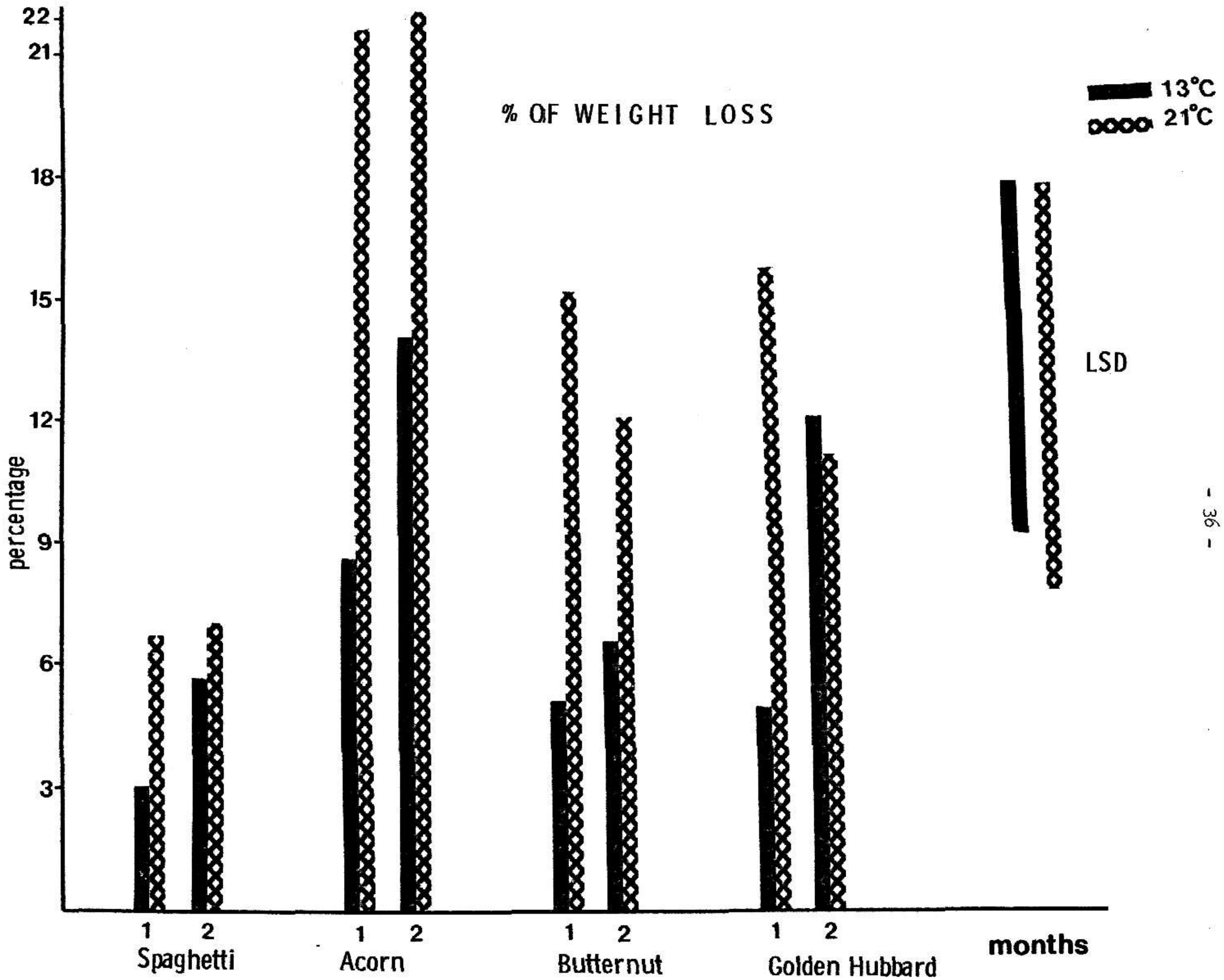

% OF WEIGHT LOSS
13°C
21°C
LSD
percentage
22
21
18
15
12
9
6
3
1 2
Spaghetti
1 2
Acorn
1 2
Butternut
1 2
Golden Hubbard
months

Fig. 2. Fructose content in winter squash cultivars that were cured, stored for 1 month or 2 months at $13^{\circ}C$ or $21^{\circ}C$.

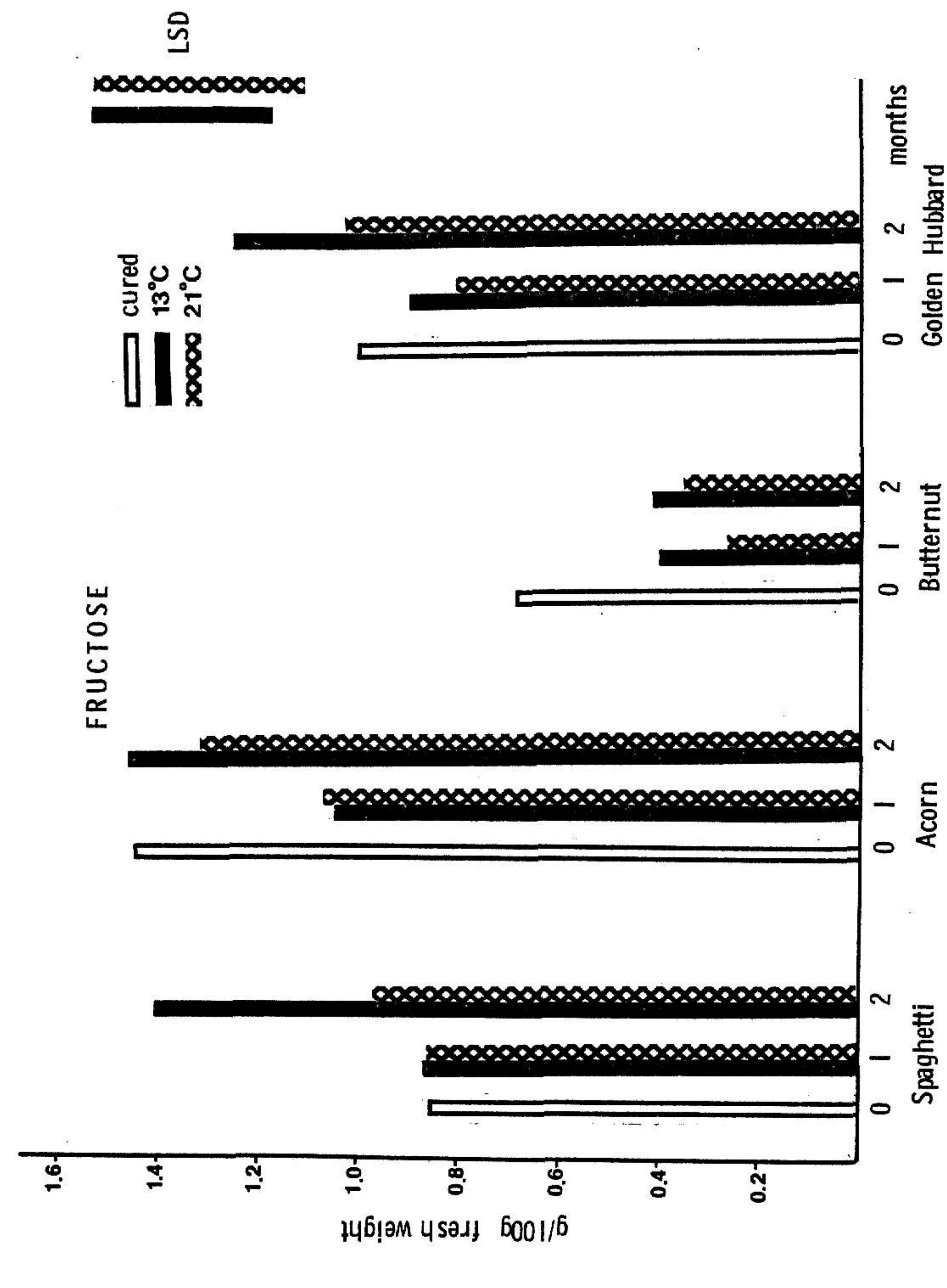

FRUCTOSE
LSD
cured
13°C
21°C
g/100g fresh weight
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0 1 2
Spaghetti
0 1 2
Acorn
0 1 2
Butternut
0 1 2
Golden Hubbard
months

Fig. 3. Glucose content in winter squash cultivars that were cured, stored for 1 or 2 months at 13°C or 21°C.

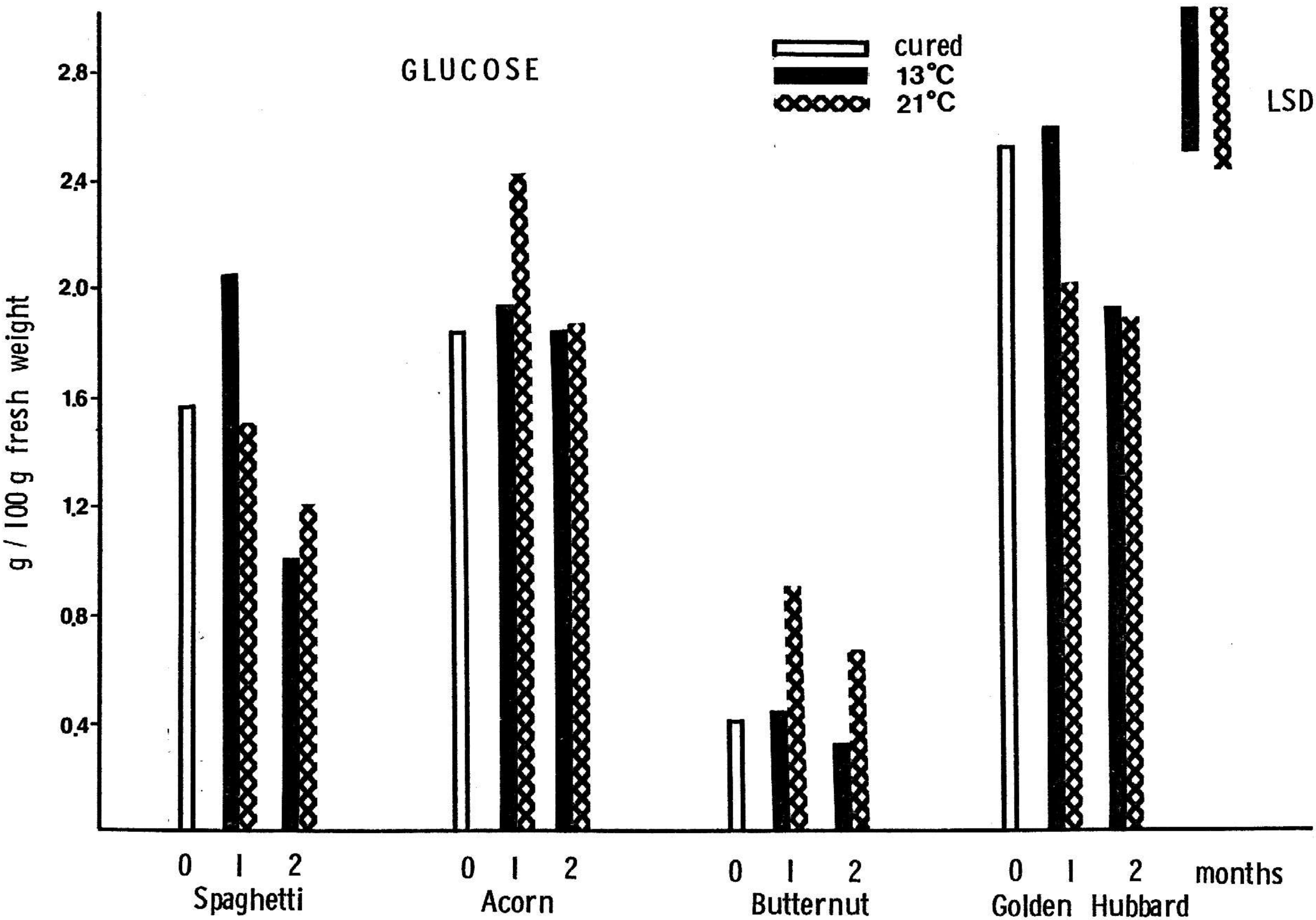

GLUCOSE
cured
13°C
21°C
LSD
g / 100 g fresh weight
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0 1 2
Spaghetti
0 1 2
Acorn
0 1 2
Butternut
0 1 2
Golden Hubbard
months

Fig. 4. Sucrose content in winter squash cultivars that were cured, stored for 1 or 2 months at 13°C or 21°C.

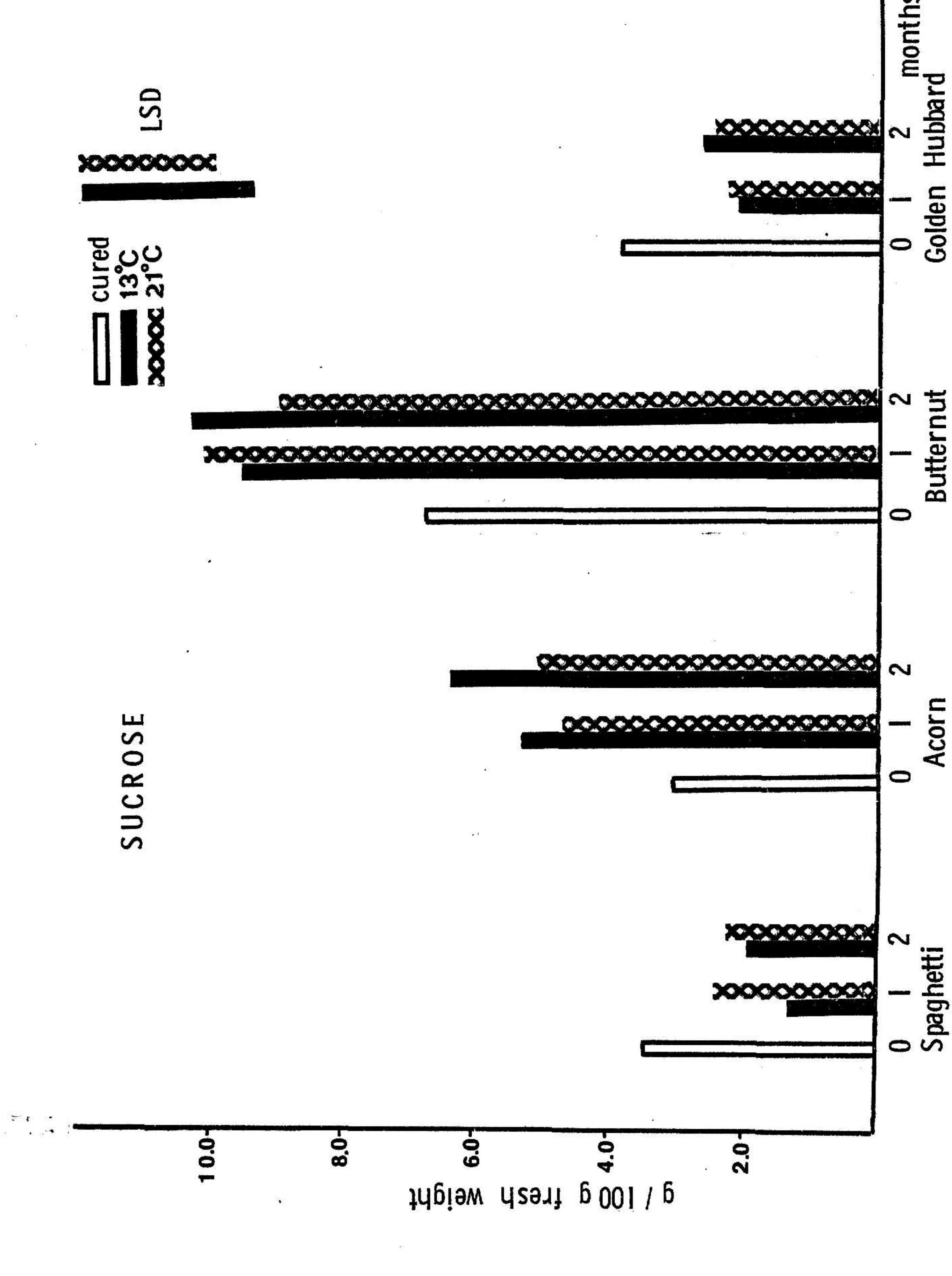

SUCROSE
cured
13°C
21°C
LSD
g / 100 g fresh weight
10.0
8.0
6.0
4.0
2.0
0
1
2
Spaghetti
Acorn
Butternut
Golden Hubbard
months

Fig. 5. β-carotene content in winter squash cultivars that were cured, stored for 1 or 2 months at 13°C or 21°C.

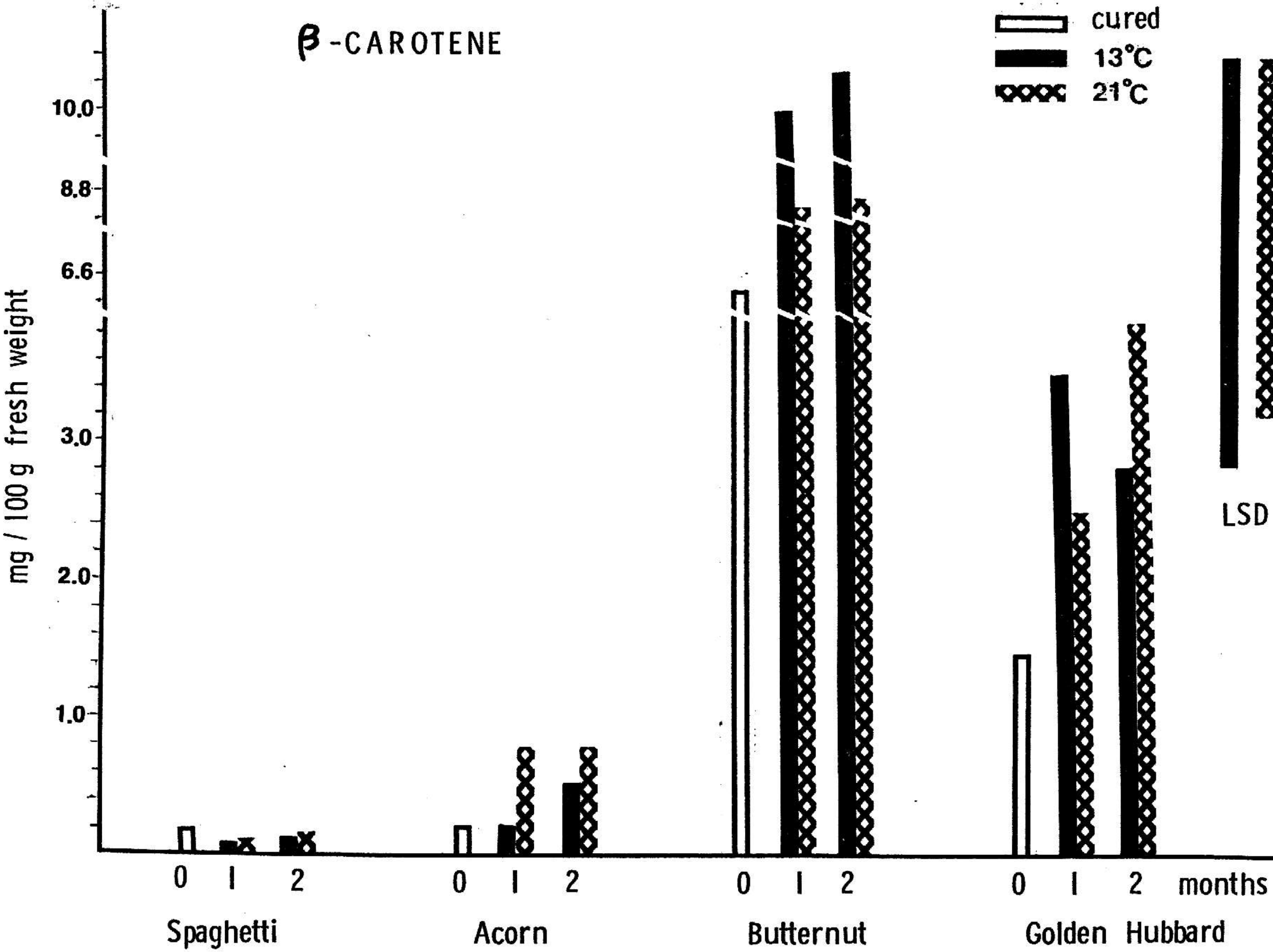

β-CAROTENE
cured
13°C
21°C
LSD
mg / 100 g fresh weight
10.0
8.8
6.6
3.0
2.0
1.0
0 1 2 months
Spaghetti
Acorn
Butternut
Golden Hubbard

Fig. 6. Rind pressure test on winter squash cultivars that were stored at 1 or 2 months at $13^{o}C$ or $21^{o}C$.

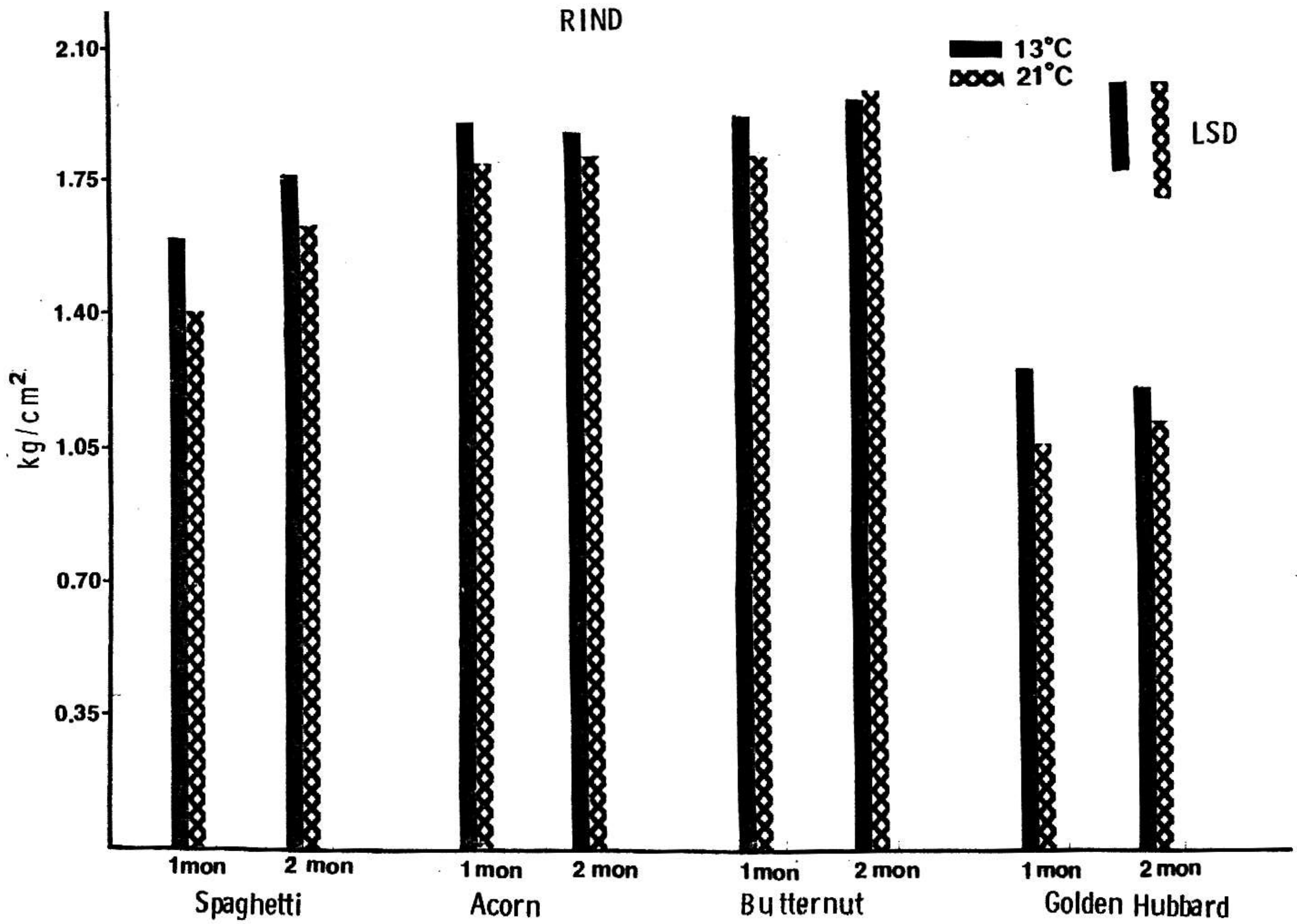
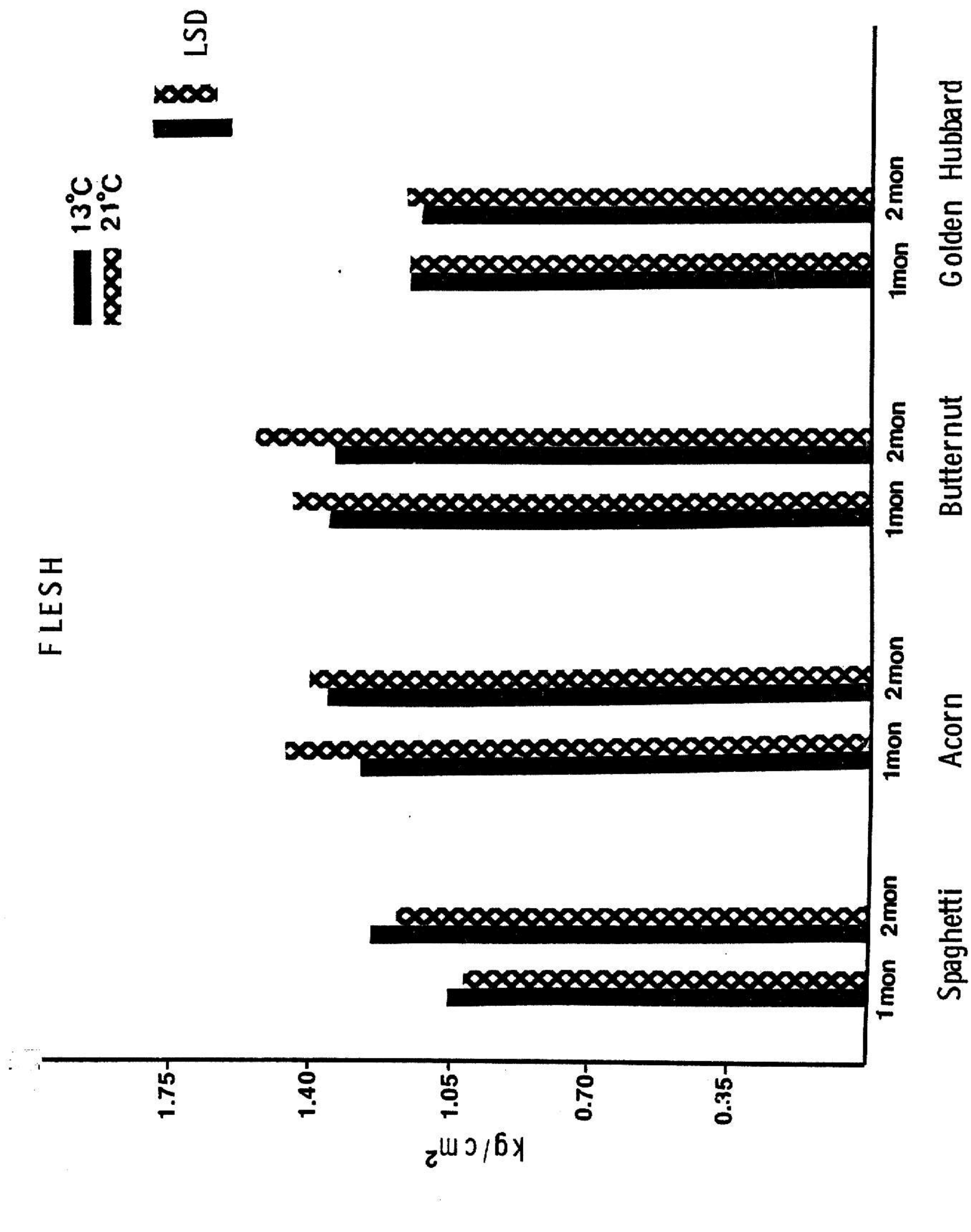

RIND
13°C
21°C
LSD
kg/cm²
2.10
1.75
1.40
1.05
0.70
0.35
1mon
2 mon
Spaghetti
1 mon
2 mon
Acorn
1mon
2 mon
Butternut
1 mon
2 mon
Golden Hubbard

Fig. 7. Flesh pressure test on winter squash cultivars that were stored at 1 or 2 months at 13°C or 21°C.


FLESH
13°C
21°C
LSD
kg/cm²
1.75
1.40
1.05
0.70
0.35
1mon
2mon
Spaghetti
Acorn
Butternut
Golden Hubbard

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VITAE

The author was born in Taiwan, Republic of China in 1955. She got her B.S. degree in Horticulture Department of the College of Chinese Culture in 1978. Then she had worked in Horticulture Department of Chia-Yi Agriculture Experiment Station for one year.

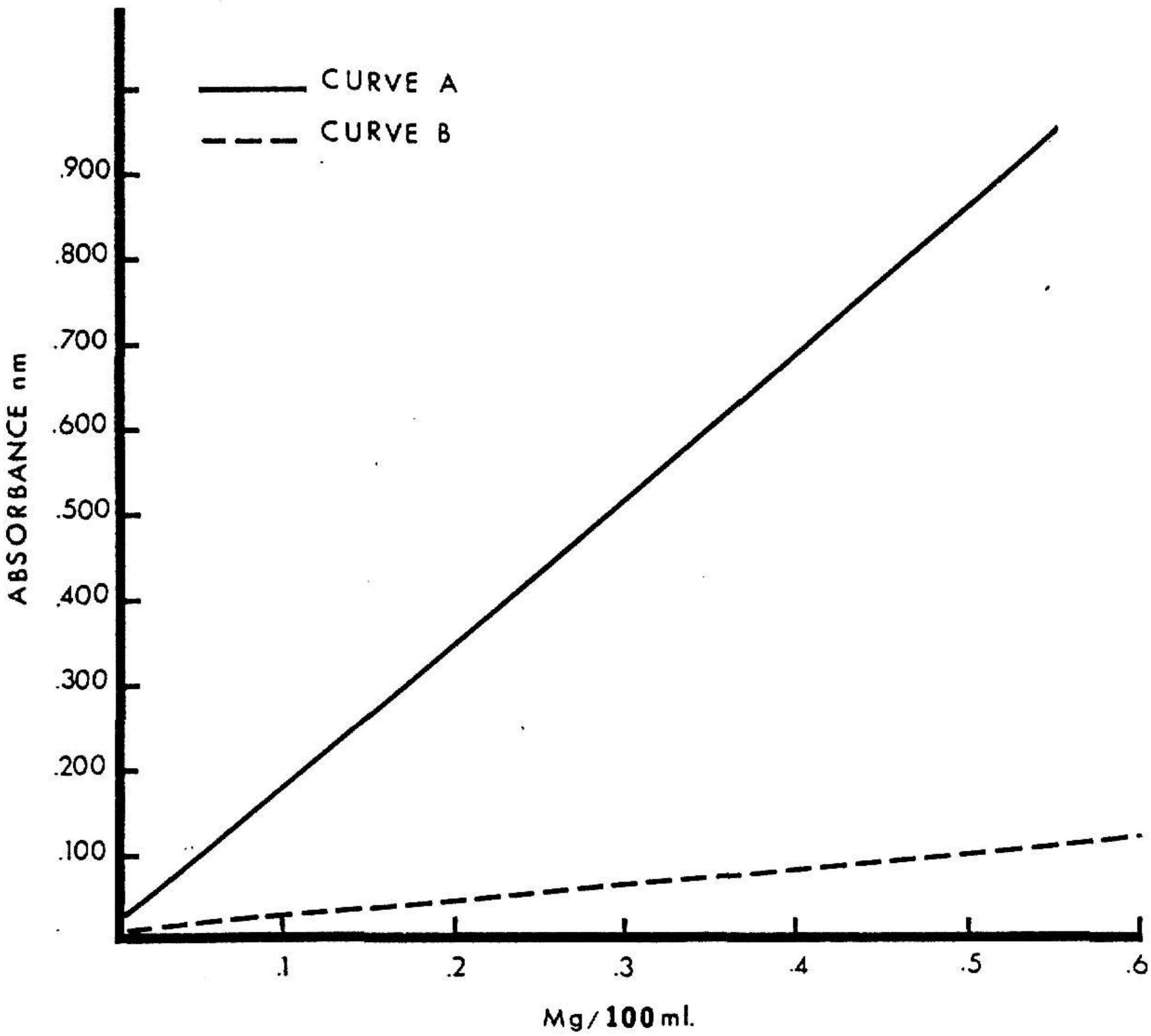
She had a desire to learn more Horticulture. She came to the United States in the spring of 1980 and worked on her Master's Degree at Kansas State University.

APPENDIX

EXPLANATION OF PLATE I

Standard curve of fructose and glucose in known concentration at temperatures of 55°C and 100°C as determined with a Beckman Spectrophotometer at a wave length of 745 nm. Curve A represents fructose and glucose at 100°C and fructose at 55°C. Curve B represents glucose at 55°C.

PLATE I


CURVE A
CURVE B
.900
.800
.700
.600
.500
.400
.300
.200
.100
ABSORBANCE nm
.1
.2
.3
.4
.5
.6
Mg/100 ml.

Reagents

Alkaline ferricyanide solution: Dissolve 160 grams of anhydrous sodium carbonate and 150 grams of disodium phosphate heptahydrate (or 79.5 grams of anhydrous disodium phosphate) in 850 ml of distilled water, add 4 grams of potassium ferricyanide, and dilute to one liter.

Arsenomolybdate solution: Dissolve 25 grams of ammonium molybdate tetrahydrate in 450 ml of distilled water. Add 21 ml of concentrated H_2SO_4, followed by 3 grams of disodium arsenate in 25 ml of distilled water. Heat at 55°C for 30 minutes in a water bath with constant stirring.

Sulfuric acid solution 2N: Dilute 56 ml of concentrated H_2SO_4 (specific gravity 1.84) to one liter.

Hydrochloric acid: Dilute 1 to 1 by volume with distilled water.

Sodium Hydroxide solution 10N: 40 grams of NaOH to 100 ml or distilled water.

Preparation of Standard Curve

Prepare glucose and fructose solution which contain 1, 2, 3, 4, 5 and 6 mg of sugar per 100 ml. Place 10 ml of these solutions in flasks and carry out reduction at 55°C and 100°C. Dilute to 100 ml and determine absorbances against mg. of sugar per 100 ml. At 100°C glucose and fructose have similar rates of oxidation, and the curves are identical. At 55°C the values for fructose were about eight times higher than those for glucose of same concentrations (Plate I).

COMPOSITIONAL CHANGES OF SELECTED SQUASH CULTIVARS UNDER DIFFERENT STORAGE TEMPERATURES FOR TWO STORAGE PERIODS

by

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Spaghetti squash is one of the newly instroduced winter squash cultivars. References pertaining to storage effects on compositional changes of this squash have not been reported. This study was desgined to evaluate the compositional changes of Spaghetti squash stored at different temperatures and two periods of storage time and to compare Spaghetti to other selected cultivars.

Four Cultivars: Spaghetti (Cucurbita pepo), Acorn (C. pepo), Butternut (C. moschta) and Golden Hubbard (C. maxima) were stored at either 13°C or 21°C. Storage periods of 0, 1 month and 2 months were evaluated. The composition of sugars (including fructose, glucose and sucrose), β-carotene, percentage of weight loss and texture test (both rind and flesh) were determined.

Spaghetti squashes content was high in fructose and glucose but lower in sucrose when compared to the other three cultivars. β-carotene content of Spaghetti squash was significantly lower than Butternut squash. Pressure test for texture of both rind and flesh, of Spaghetti squash was firmer than Golden Hubbard. Spaghetti squash also had lower percentage of weight loss than Acorn at 21°C.

Fructose and glucose content of Spaghetti squash increased after 2 months storage at 13°C. Flesh test of this squash was firmer after 2 months storage at both 13°C and 21°C. It was found no effects of storage time on sucrose and β-carotene content, and percentage of weight loss.

From data in this study, Spaghetti squash contained high value of fructose and glucose, but was not a good source of β-carotene, provitamin A. Low percentage of weight loss during storage indicates that Spaghetti squash has a good potential for storage.