

Nuts and Bolts of Nutrition and Eating Quality in Winter Squash



Brent Loy, Biological Sciences
University of New Hampshire
NH Agricultural Experiment Station

What comes to mind when discussing nutrition ?

- Caloric intake
- Vitamins
- Minerals
- Improved digestive function – dietary fiber
- Fats, proteins and carbohydrates

Nutritional Benefits of Squash

Carbohydrate source:

sugars (glucose, fructose → sucrose)

starch –

Carotenoids –

- **β -carotene:**
- **lutein:**

Dietary fiber – insoluble (cellulose) and soluble (pectins)

Other vitamins

Ash (mineral elements) – high in K

Percentage dry weight composition of the edible portion of buttercup and butternut squash.^z

<u>Component</u>	Percent of total	
	<i>At harvest</i>	<i>3 months</i>
Storage carbohydrates	62-68	57-62
starch	52-53	14-19
sugars	10-15	43
Cell wall (cellulose, pectin)	9-10	13-17
Protein (values high)	5-6	6-8
Ash (mineral elements)	5-6	5-6
<u>Other</u>	<u>10-16</u>	<u>8-19</u>

^zAdapted from T.G. Phillips, 1946.

Carotenoid Composition in Squash ($\mu\text{g}/100\text{ g}$ serving)

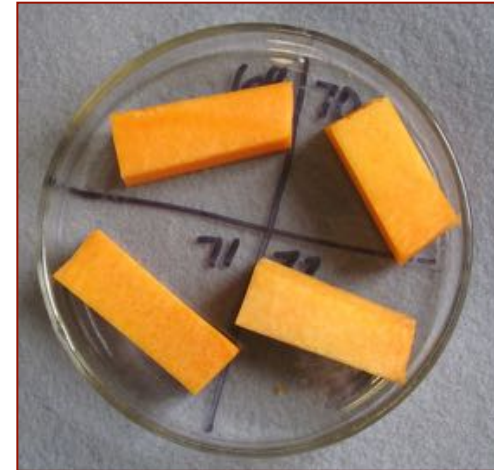
<u>Squash group</u>	<u>B-carotene</u>	<u>lutein</u>
Acorn squash	600	800
Kabocha squash	3500	4600
Butternut squash	1700	2700

What comes to mind when discussing eating quality?

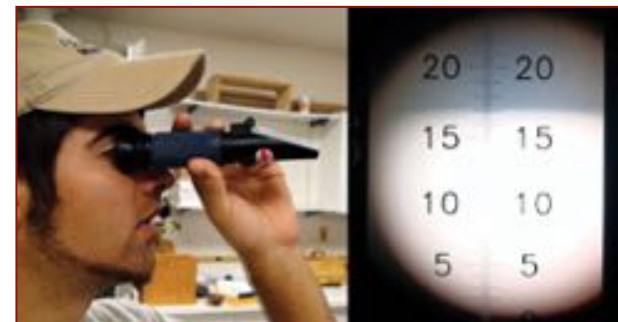
- Taste
- Smell
- Texture
- Consistency
- Sweetness
- Stringiness

How do we evaluate starch and sugar in squash?

% DW (solids or dry biomass)
shows a strong positive
correlation to **starch** content:



% soluble solids (SS)
correlates with **sugar** content.
(11% or greater)



Squash samples cooked in microwave.

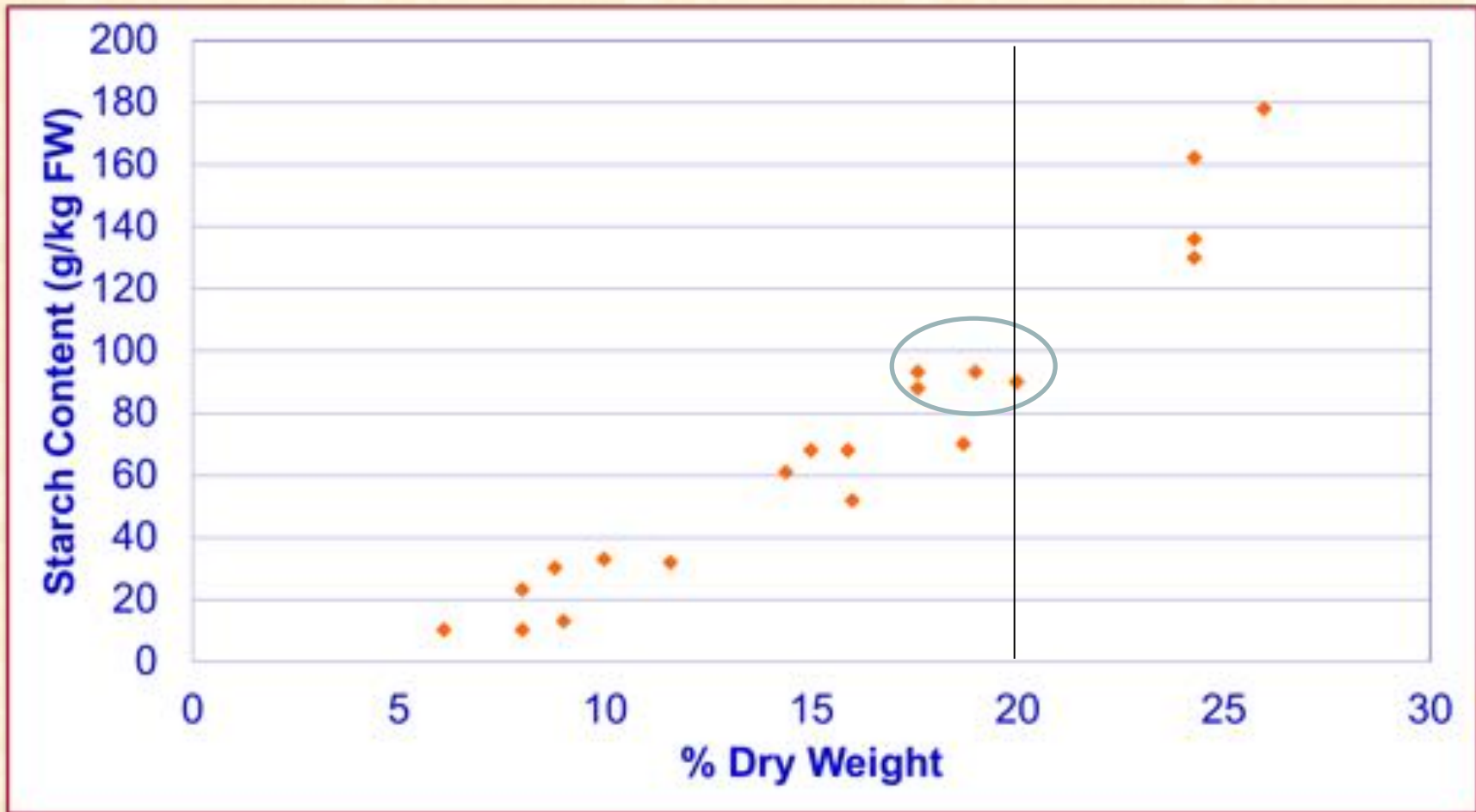


Kaitlyn Orde

Starch provides acceptable textural properties and consistency.

- Starch absorbs moisture through the process of gelatinization during cooking.
- Low starch - excessively moist and fibrous texture.
- Extremely high starch levels - dog bone texture

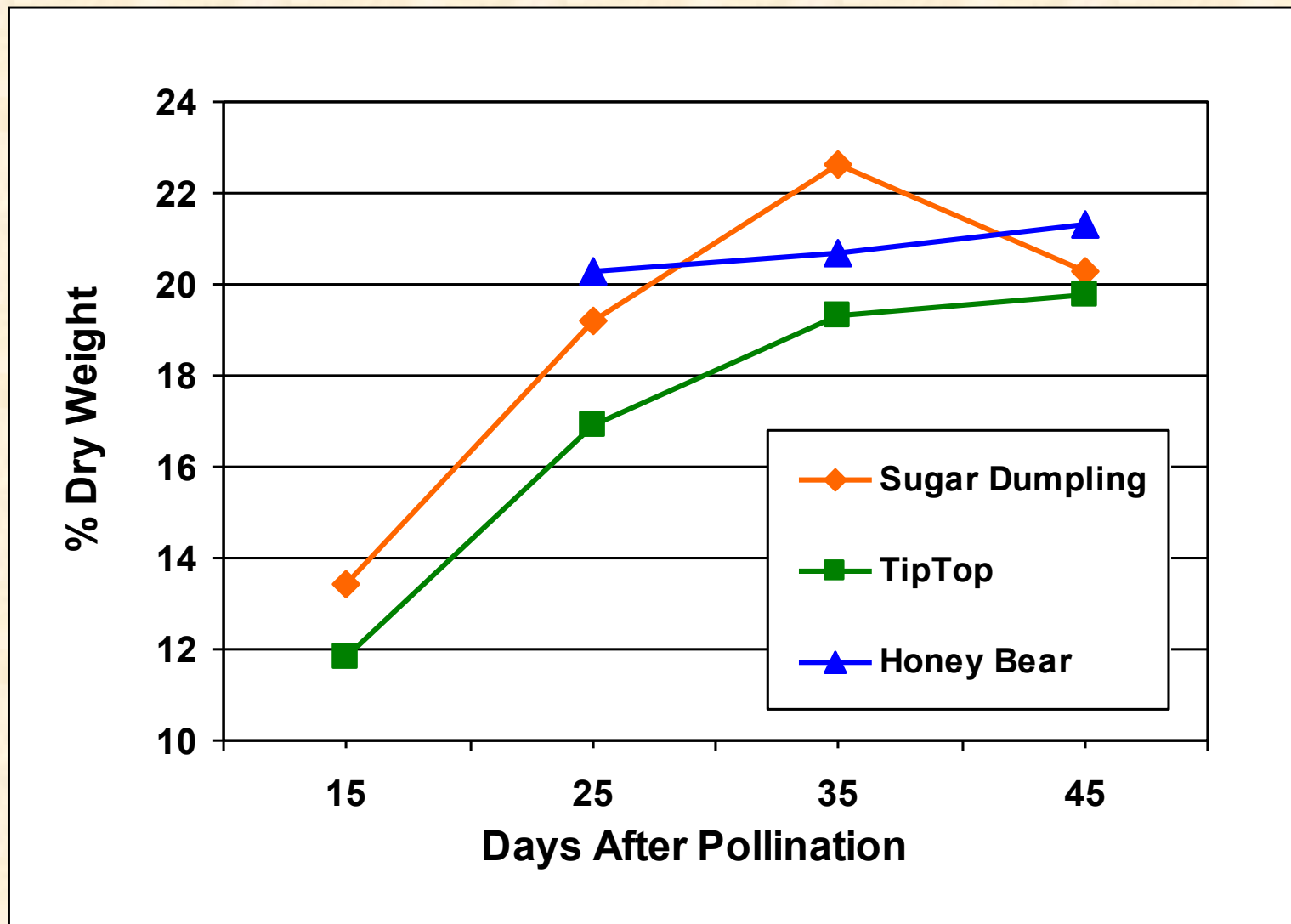
How much starch?



Starch is the storehouse for sugars.

- Enzymes convert starch to sugar during fruit maturation and storage.
- Sugars are an energy source utilized during respiration.
- Sugars increase palatability of squash flesh.

Time-course of starch accumulation.



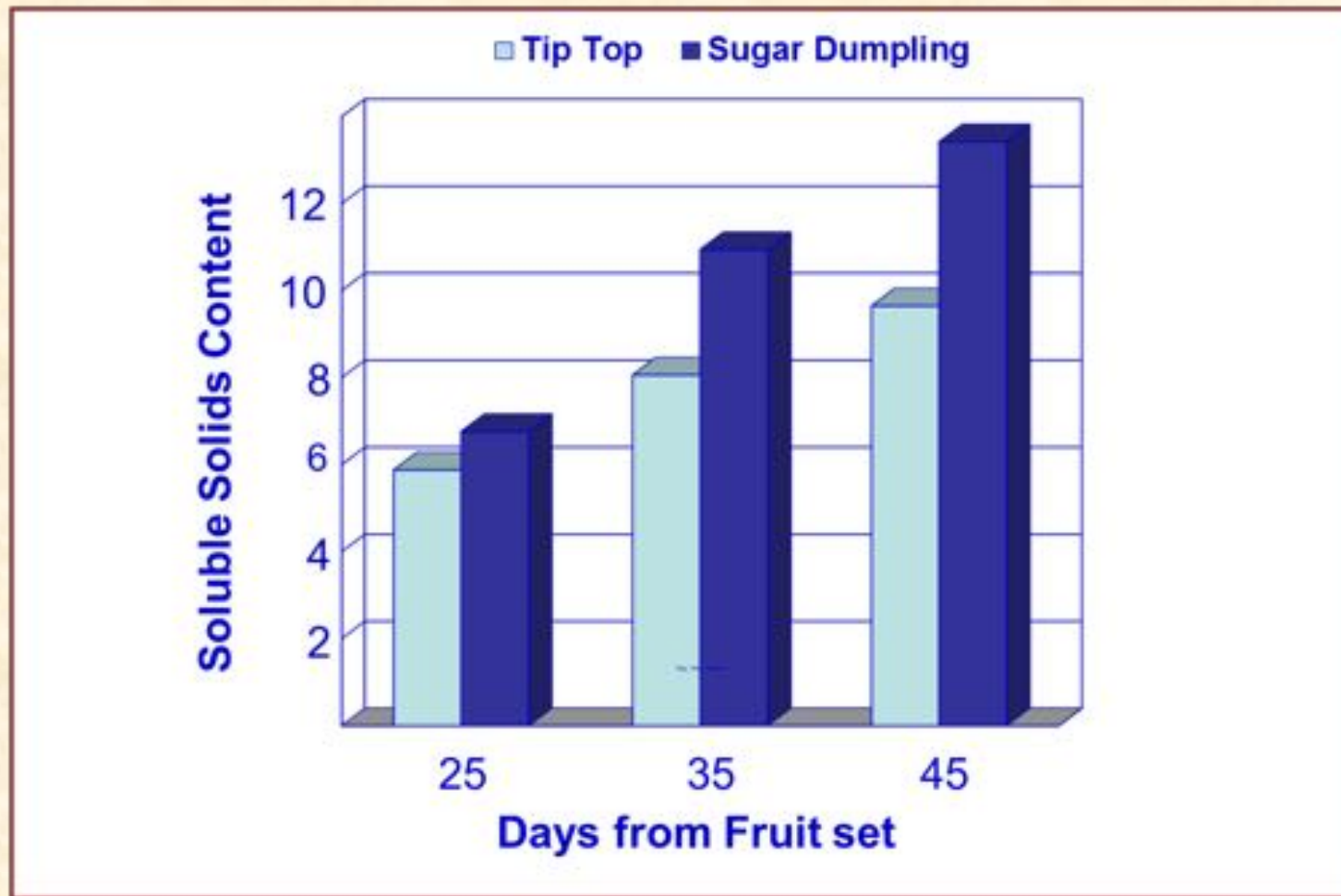
Will be exceedingly difficult to introduce high quality acorn varieties into the wholesale trade.



1. In large supermarkets, only the classical larger-fruited acorn squash are offered. (filler vegetable)
2. Squash sold in large supermarkets are often harvested immature.

Are there species differences in maturation of squash for good eating quality?

Acorn Group



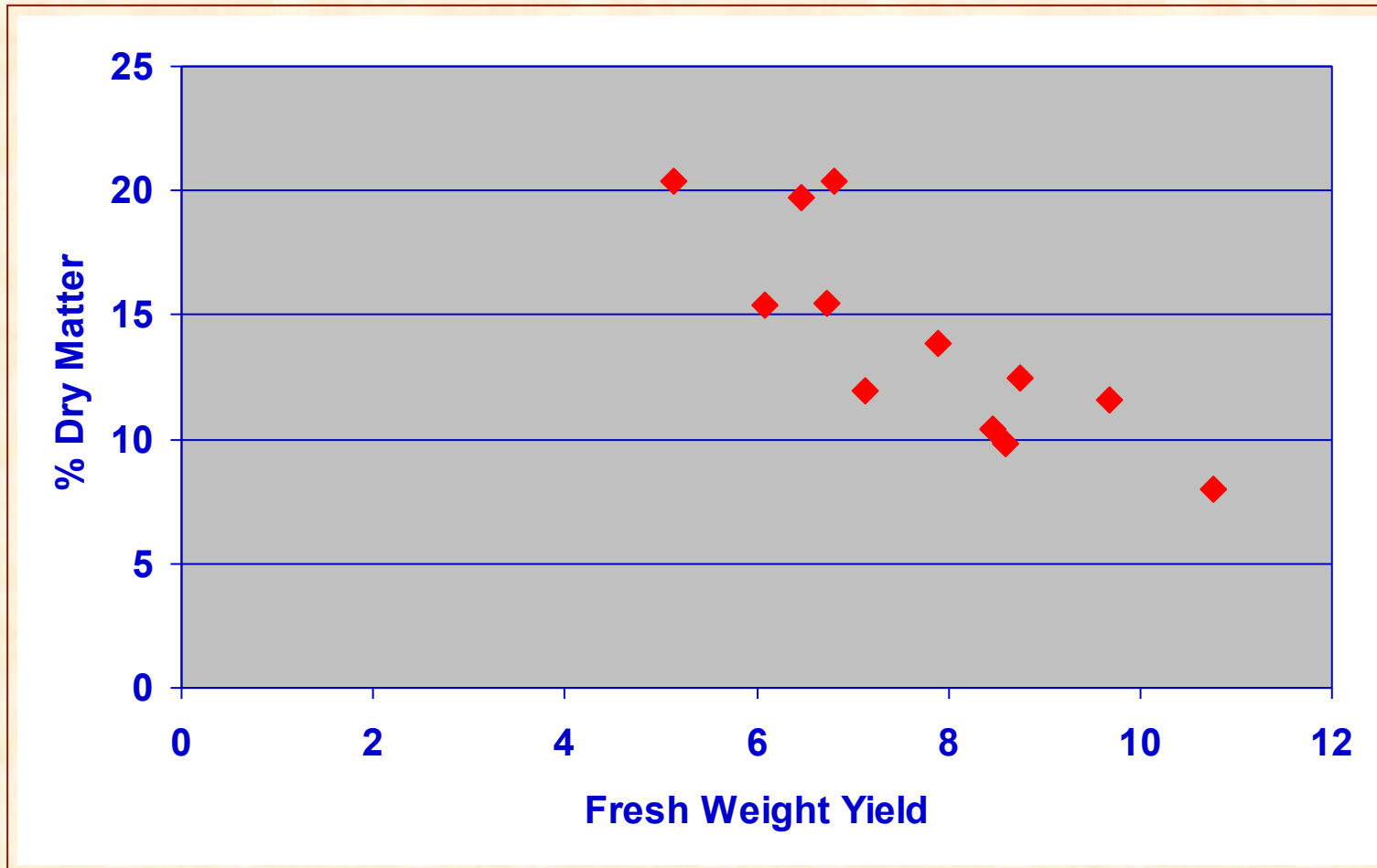
Comparison of Quality Traits in Commercial Hybrids with PMR (2011)

Hybrid	Fruit size (g)	%DM	SS
Honey Bear	645 A	15.4 D	11.5 C
NH1669	761 B	19.8 E	14.4 D
Autumn Delight	981 D	8.0 A	6.8 A
Royal Ace	786 BC	9.8 B	8.1 AB
Tip Top	857 C	12.5 C	9.5 B
Table Star	756 B	11.6 C	8.8 B

Seasonal Differences in % DW

<u>Hybrid</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>
Honey Bear	15.4_	18.6	
Sugar Bush	21.5_	21.6	18.7
Autumn Delight	8.0_	11.4	9.4
Tip Top	12.5_	17.6	17.1
Table Treat	12.7_	13.3	12.9

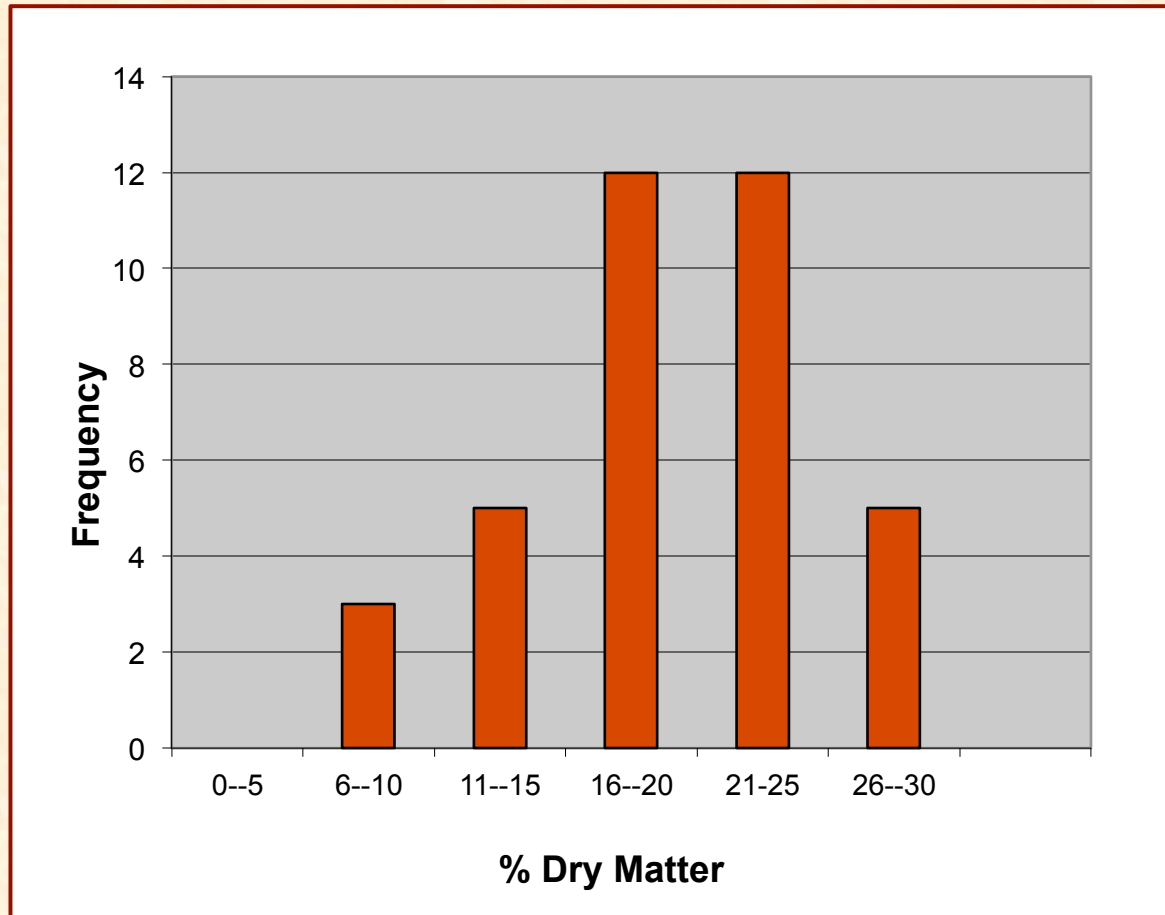
Fresh weight yields are reduced when dry matter is elevated in fruit mesocarp tissue.



Acorn group (green and striped acorns):

- Acorns purchased from farmers retail markets should be marketed by **variety 'name'** .
- Good varieties:
 - Honey Bear (UNH),
 - Sugar Dumpling (UNH)
 - Sugar Bush (UNH)
 - Bush Delicata (Cornell)
 - Sweet Dumpling (older variety)
 - Delicata (older variety)
 - Jester (JSS)
 - Tip Top (JSS)

Uniform Eating Quality an Issue in Acorn Varieties



NH1669

Effect of Fruit Pruning on % DW

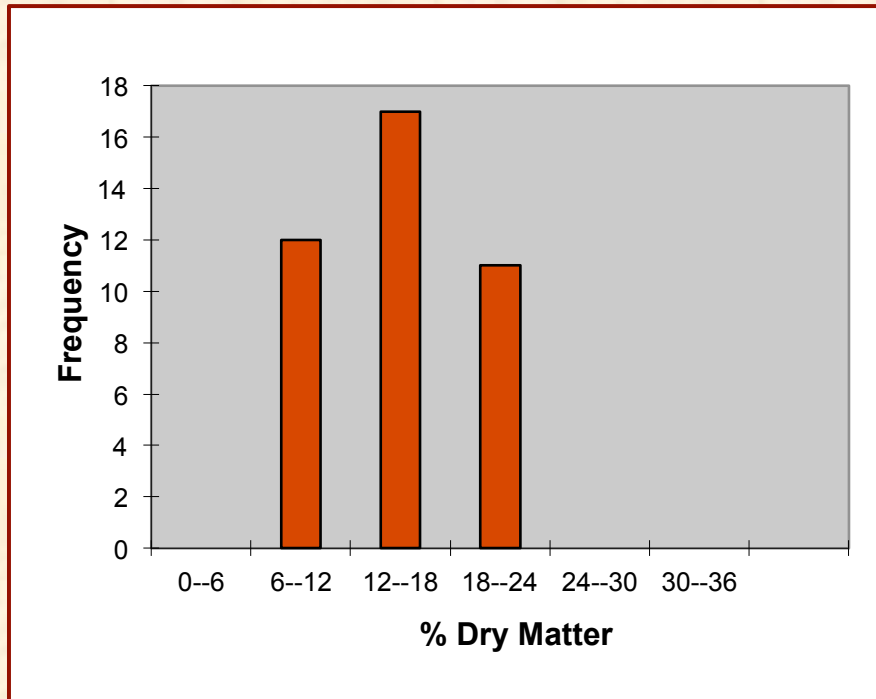
(control versus pruned to 3 fruit)

Hybrid	Pruned		Unpruned	
Honey Bear	20.6	A	15.4	B
NH1669	20.4	A	19.8	A
Autumn Delight	10.4	A	8.0	B
Royal Ace	12.0	A	9.8	A
Tip Top	13.8	A	12.5	A
Table Star	15.4	A	11.6	B

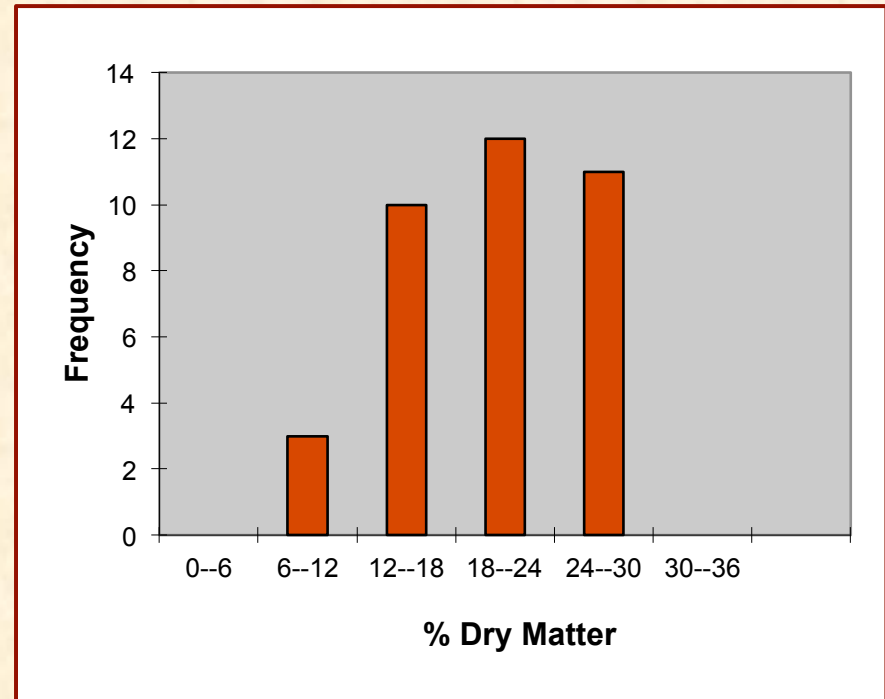
Values within rows followed by the same letter are not significantly different at $P = 0.05$.

% DW Distribution in Control and Pruned Plants of Honey Bear

Control plants

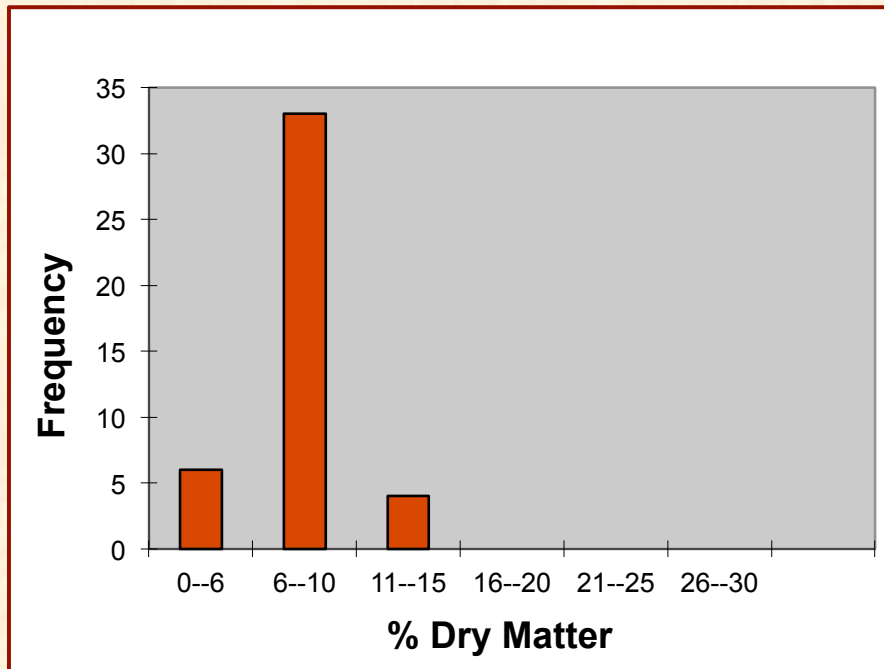


Pruned plants

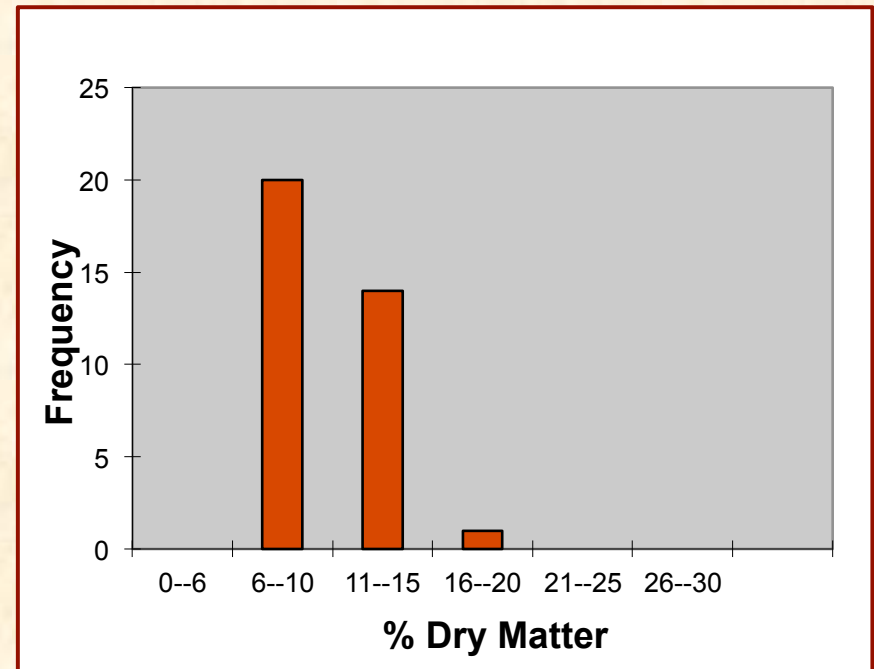


% DW Distribution in Control and Pruned Plants of Autumn Delight

Control



Pruned



Grafted Acorn Squash on Interspecific Hybrid Rootstock NH1310 (NH65 x SC936)

Randomized design with 3 replications and 6 plants per plot.

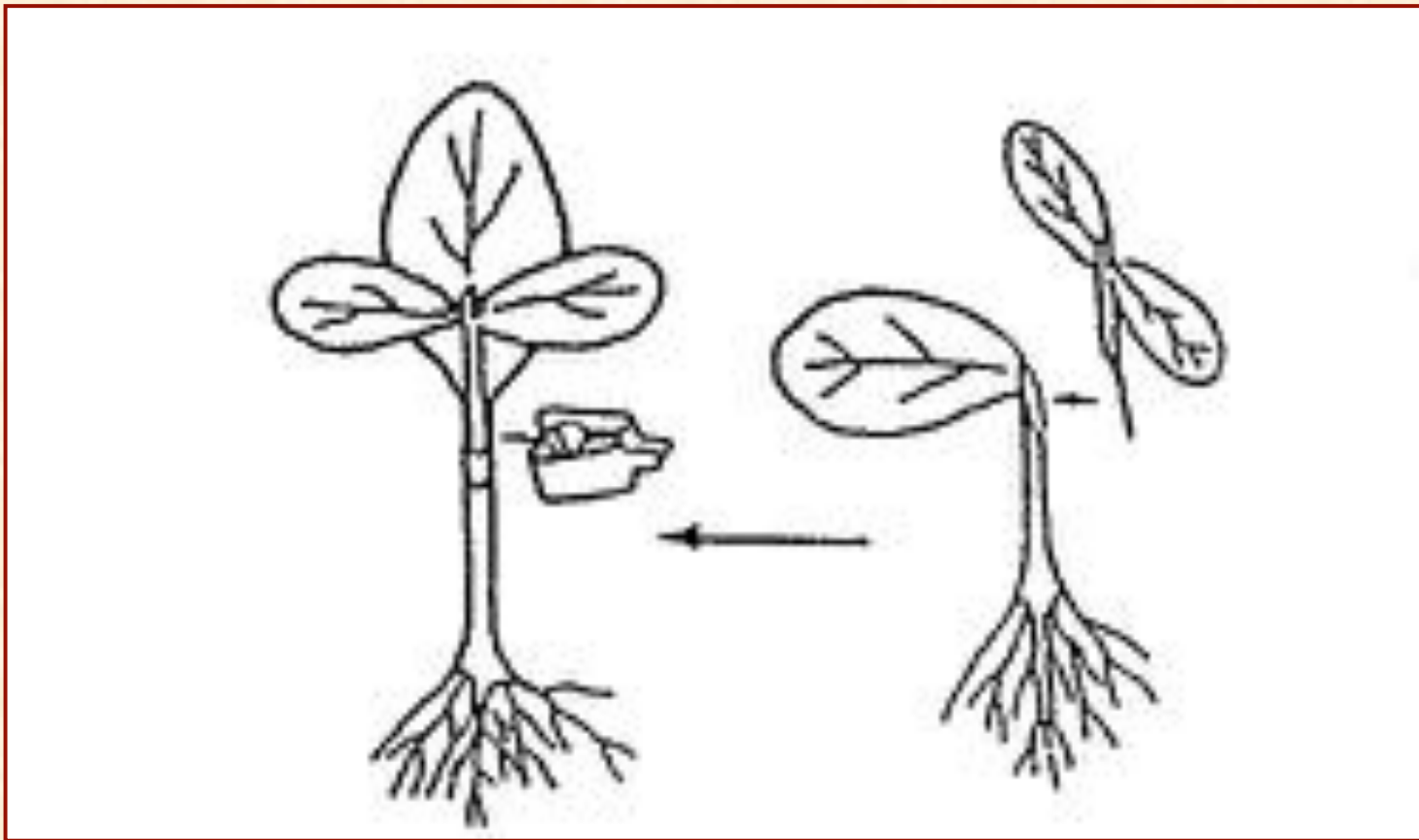
Two varieties:

Honey Bear

Autumn Delight

Grafting method: single cotyledon splice graft.

Single Cotyledon Grafting Technique



Honey Bear Grafting Results

(3 replications, 5 samples per replication)

<u>Treatment</u>	<u>Ave. fr. no. per plant</u>	<u>Ave. fr. wt. per plant</u>	<u>Ave. fr wt. (g)</u>	<u>% DW</u>	<u>% SS</u>
Control	3.8 a	2.2 a	583 b	17.6 a	13.1 a
Grafted	4.7 b	2.7 b	541 a	17.0 a	12.2 a

Fruit set between July 6 and 12; harvested Sept. 28.

Autumn Delight Grafting Results

(3 replications, 5 samples per replication)

<u>Treatment</u>	<u>Ave fr. no. per plant</u>	<u>Ave fr wt. per plant</u>	<u>Ave. fr. wt. (g)</u>	<u>% DW</u>	<u>% SS</u>
Control	3.9 a	3.2 a	809 a	9.6 a	8.3 a
Grafted	5.3 b	4.2 a	800 a	11.9 b	10.4 b

Fruit set between July 6 and 12; harvested Sept. 28.

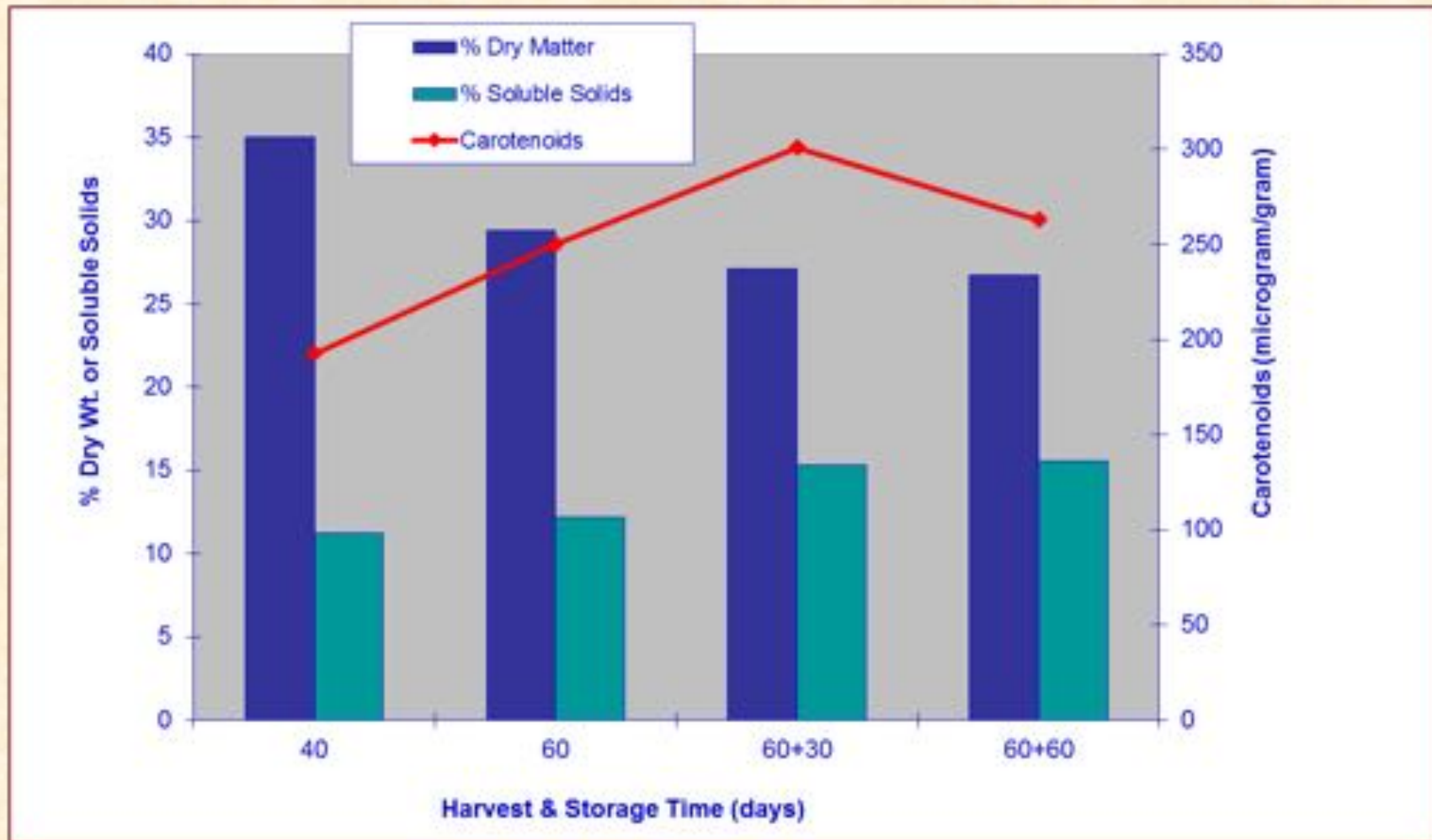
Kabochoa/Buttercup Group



Rind color of kabocha/buttercup squash reach dark green color by 40 DAP. If vines are down at this time, should harvest to reduce sunburn damage and bronzing of fruit, but follow that with storage for at least three weeks.



Harvest and storage time affects eating quality and nutritional content of kabocha squash (NH5272).



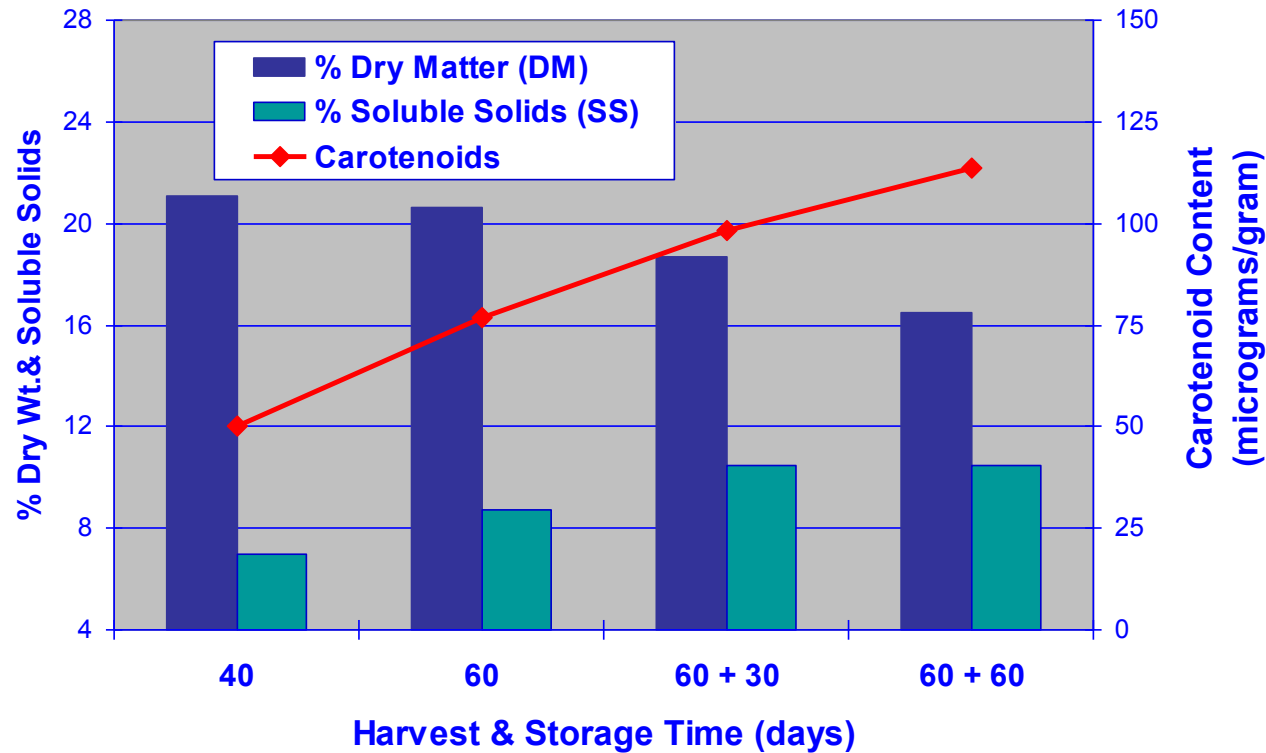
Butternut Group



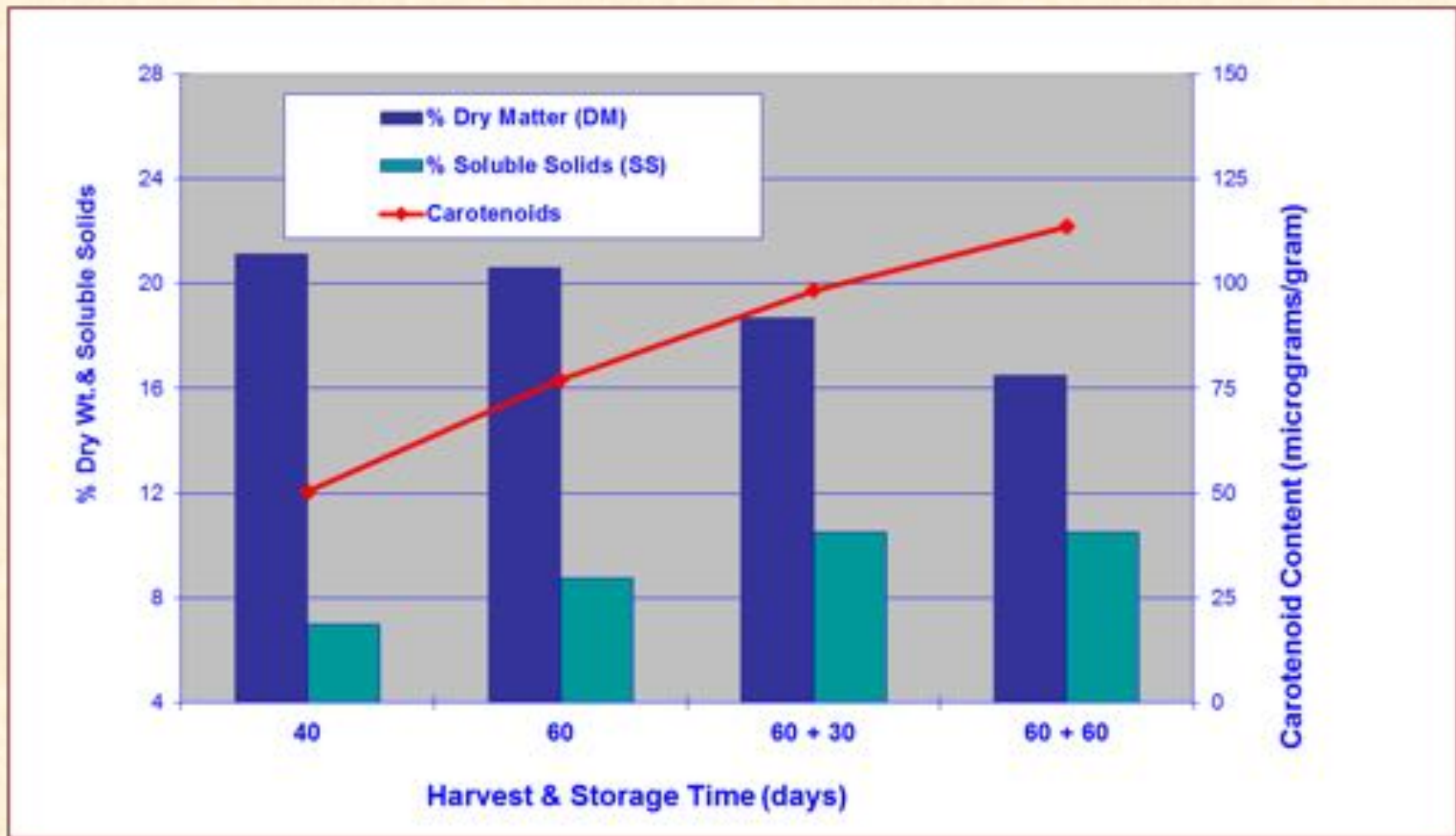
The rind of butternut squash turns tan by 35 to 40 days after fruit set, two or more weeks before seed fill is complete.



Harvest date and storage time affects eating quality and nutritional content of 'Waltham' butternut squash.



Harvest date and storage time affects eating quality and nutritional content of 'Waltham' butternut squash.



Summary

- Harvest dates and storage times to achieve optimum eating quality and nutritional value in squash have to be tailored to particular species and variety.
- Optimum harvest periods and storage times for best eating quality are similar to those for best nutritional value.
- Future varieties may be bred for better nutritional value which could be used as a marketing tool.

Acknowledgements

Dean Jon Wraith

Hua Cui -

Research Technician

Renee Cantara -

Research Technician

Kaitlyn Orde -

Research assistant

Janel Martin -

Graduate student

John McLean -

Farm Manager

Evan Ford -

Farm Manager

David Goudreault -

Greenhouse Manager



United States Department of Agriculture
National Institute of Food and Agriculture



University of New Hampshire
NH Agricultural Experiment Station

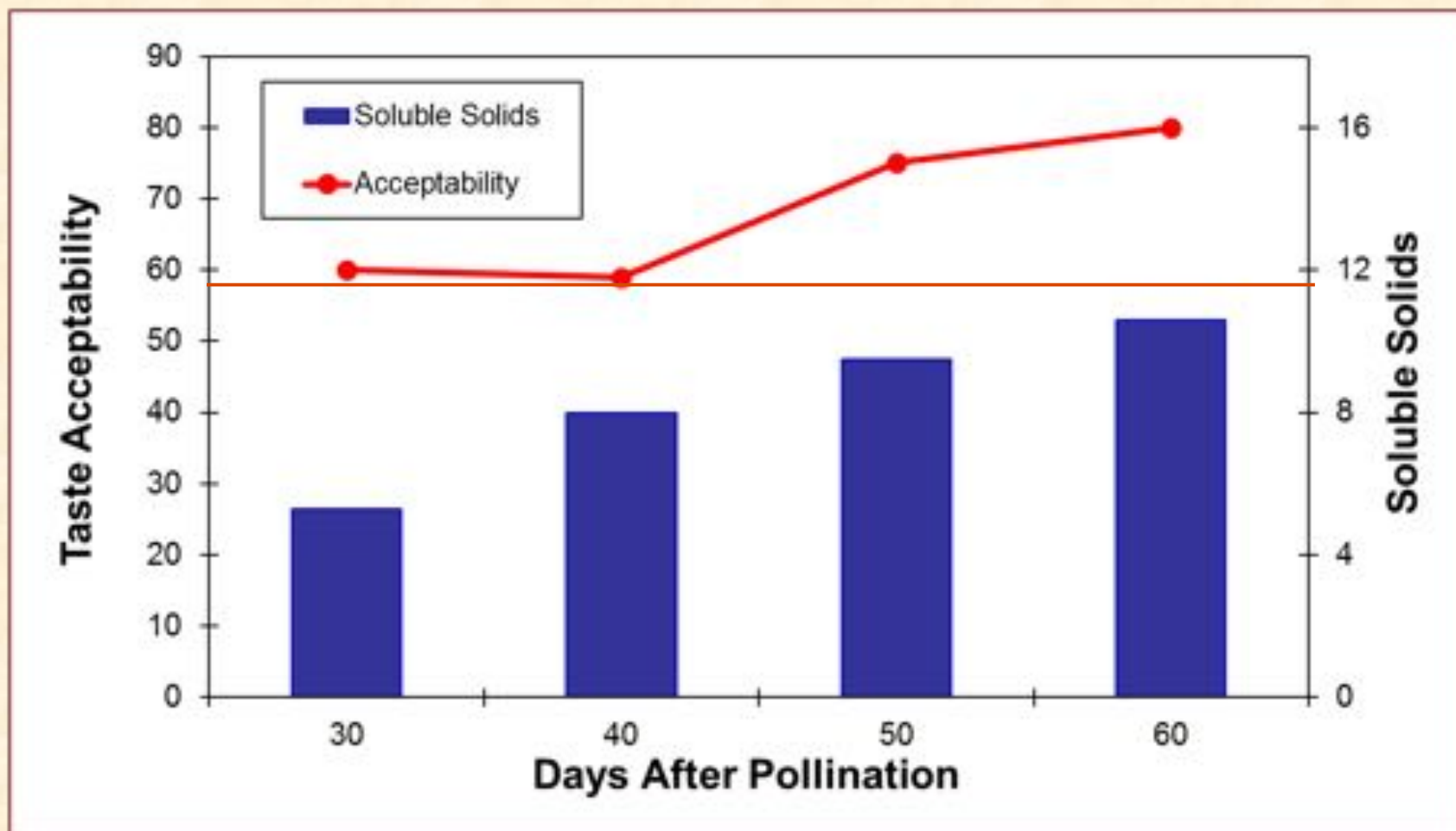


Questions

Harvest and storage time affects eating quality
and nutritional content of kabocha squash (NH5272).

How much sugar for good eating quality?

Data from 'Delica' kabocha squash at different harvest dates.

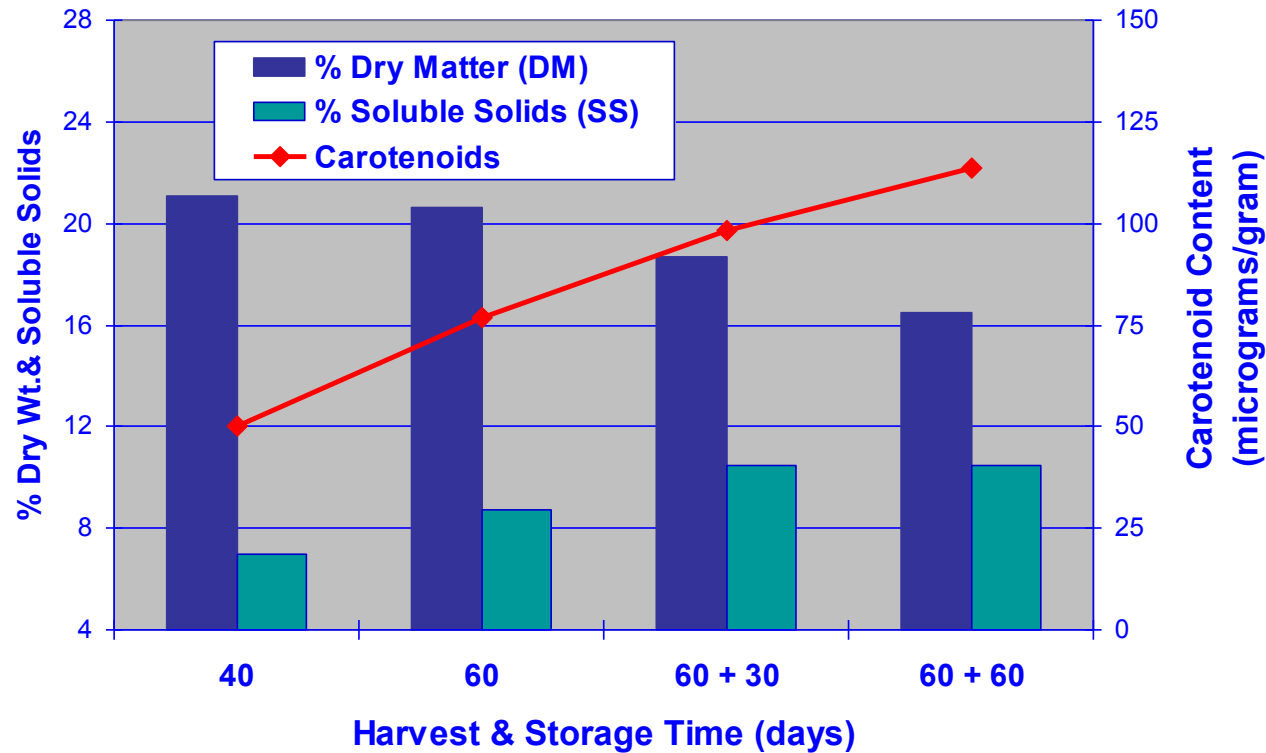


Harvey, Grant and Lammerink. 1997. NZ J. Crop & Hort. Sci. 25:341-351

Major Traits Affecting Eating Quality in Winter Squash

- 1. Solids (% DW) or dry biomass:** minerals, cellulose, pectins, sugars, starch, protein
- 2. Sugar levels (estimated as % soluble solids or °Brix):** sucrose, fructose and glucose
- 3. Texture:**
 - poor = watery and mushy **or** very dry and chalky
 - fair = moist and fibrous, somewhat sweet
 - good = moderately moist and grainy, sweet
 - vg = moderately dry and pasty; very sweet
 - excel = dry and pasty or slightly flaky; very sweet

Harvest date and storage time affects eating quality and nutritional content of 'Waltham' butternut squash.

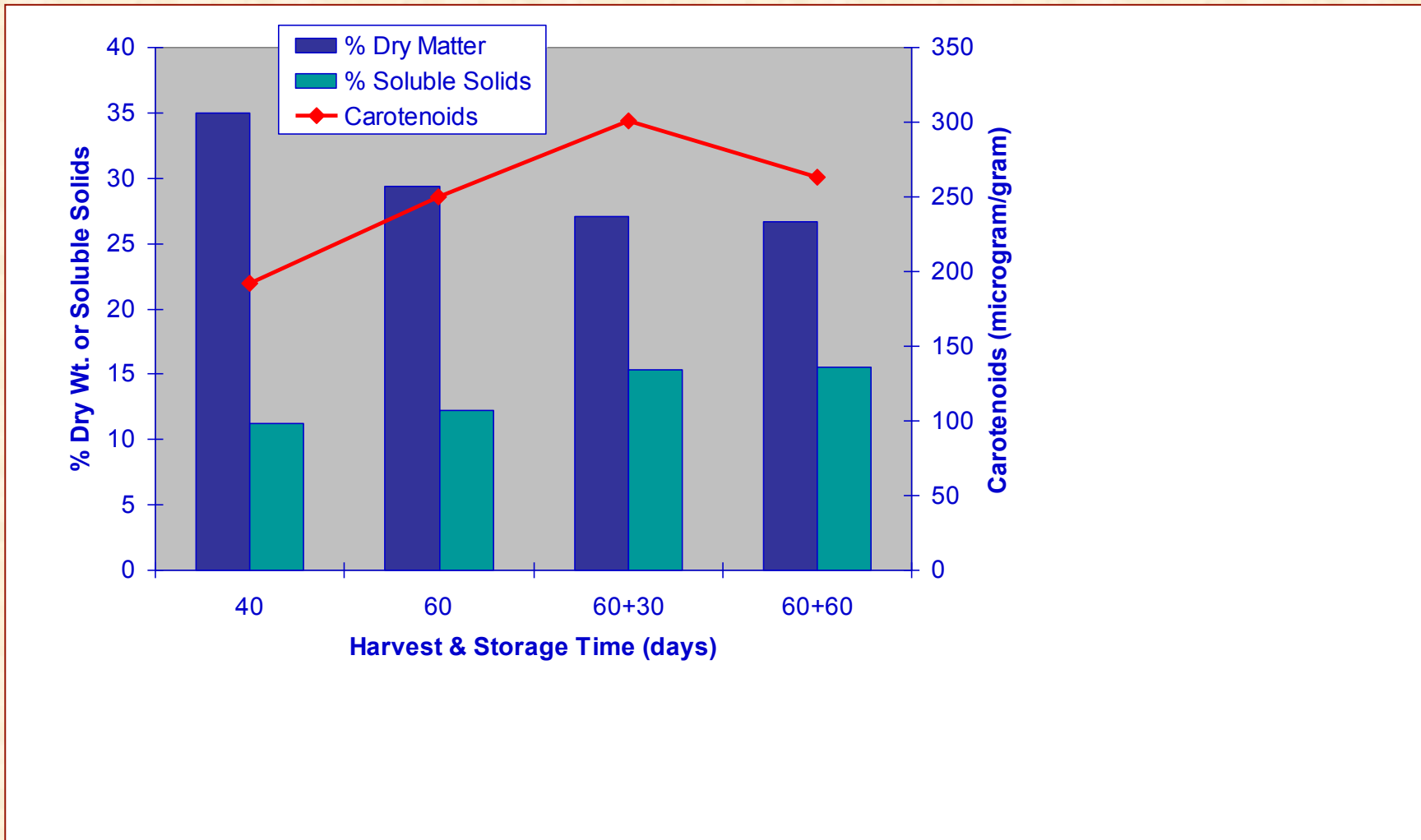


Large Differences in Carotenoid Contents of Beneficial Carotenoids Among Groups of Squash

Why are carotenoids important?

- β -carotene and α -carotene are converted to vitamin A in humans.
 - 6-12 units of β -carotene = 1 unit of Vit. A
 - 12-24 units of α -carotene = 1 unit of Vit. A
- Vitamin A (retinoic acid) important in growth and development and eye function.
 - severe deficiency worldwide
- Lutein and zeaxanthin – carotenoid pigment in the retina region of the eye and also in skin tissue. Photo protection from ultraviolet rays of the sun.

Harvest and storage time affects eating quality and nutritional content of kabocha squash (NH5272).



Mineral Composition of Squash

Element	Symbol	100 g	28 g	% Daily	
		Fruit	Seeds	Requirement	
		mg	mg	Fruit	Seeds
Potassium	K	290	223	15	11
Phosphorus	P	150	333	21	48
Calcium	Ca	42	15	4	1
Magnesium	Mg	80	156	21	41
Iron	Fe	0.60	1.1	5	9
Manganese	Mn	0.20	1.3	5	32
Copper	Cu	0.05	0.4	2	18
Zinc	Zn	0.15	2.2	1	17
Selenium	Se	0.50	2.7 μ g	1	4

Acorn fruit may appear mature in appearance within two to three weeks after fruit set.

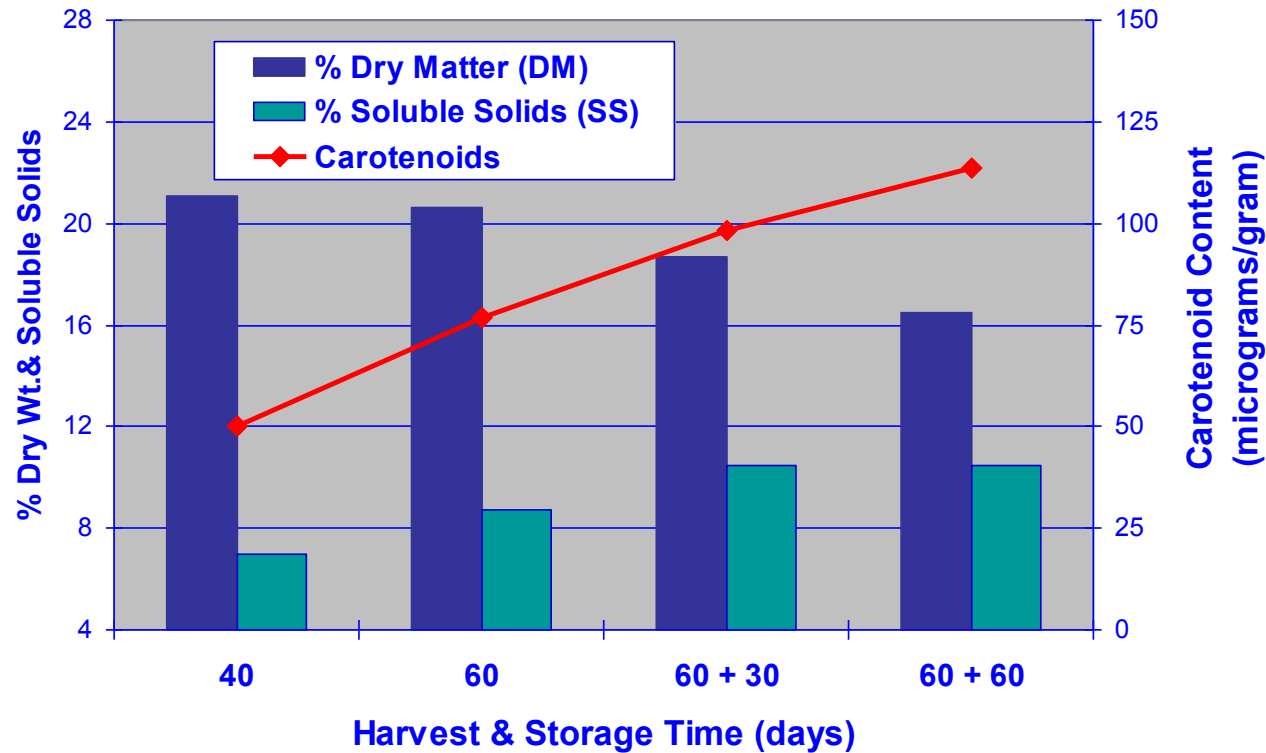


Cultivar 'Jet' 11-13 DAP



Ground spot on 'Jet'

Harvest date and storage time affects eating quality and nutritional content of 'Waltham' butternut squash.



Summary

- Harvest dates and storage times to achieve optimum eating quality and nutritional value in squash have to be tailored to particular species and variety.
- Optimum harvest periods and storage times for best eating quality are similar to those for best nutritional value.
- Future varieties may be bred for better nutritional value which could be used as a marketing tool.

Kabocha (or Buttercup) group:

- Kabocha squash shipped to Japan must pass quality muster: > 20% dry weight & 11% soluble solids.
- Quality determination in U.S.
- Most kabocha varieties when harvested properly have good eating quality.
- Kabocha marketed during winter in supermarkets sometimes is harvested prematurely – look for orange skin on ground side where squash was not exposed to sun. If skin is yellow then was harvested prematurely, resulting in low sugar and carotenoid content.
- Varieties developed at UNH: Thunder, Eclipse, Space Station, Autumn Cup (moderate quality), and Bagheera.

Butternut Group

- Waltham butternut developed at Waltham experiment station in Massachusetts in 1970 is still the dominant variety (relatively good eating quality if harvested and store
- Most butternuts have less than half the carotenoid content of kabocha squash, but have relatively high contents of both lutein and b-carotene.
- New varieties are being developed at the NH Agricultural Experiment Station which have improved uniformity and higher carotenoid content than current varieties, and will have intermediate resistance to powdery mildew disease.

Purchasing Hints for Squash

1. Many squash sold in supermarket, especially during the winter, are harvested prematurely.

Look for ground spot on squash (where it lay on the ground and was not exposed to sunlight). If ground spot is light green or yellow, then squash is immature. If groundspot is orange, then squash will at least have been harvested close to the proper time.



Acknowledgements

Hua Cue -	Research Technician
Jake Uretsky -	Graduate student
Jennifer Noseworthy -	Graduate student
Kaitlyn Orde -	Research assistant
John McLean -	Farm Superintendent
David Goudreault -	Greenhouse Manager



















At UNH, our emphasis has been on breeding high quality acorn



Honey Bear

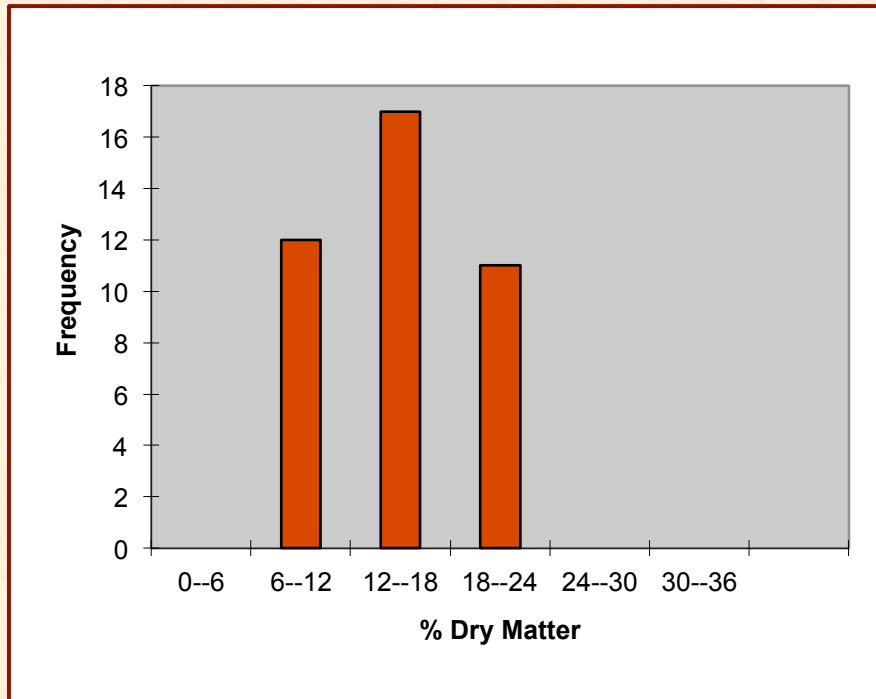
1. High dry matter content – average 20%.
2. Early sugar accumulation.
3. Bush or semi-bush phenotype for easier culture.
4. Powdery mildew resistance (PMR).

Study of Eating Quality in Hybrid Acorns in 2011

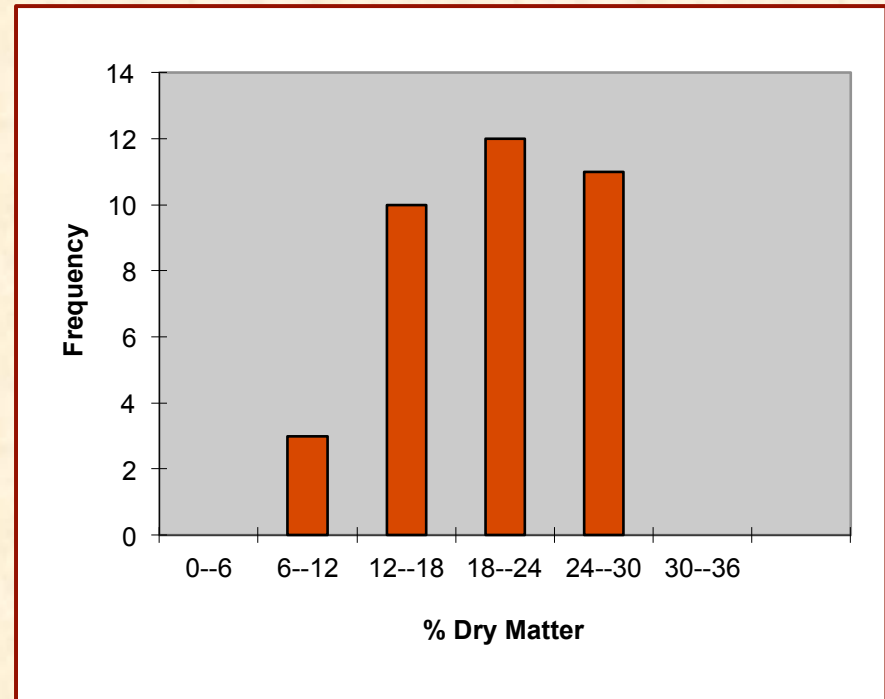


% DW Distribution in Pruned and Unpruned Plants of Honey Bear

Unpruned plants



Pruned plants



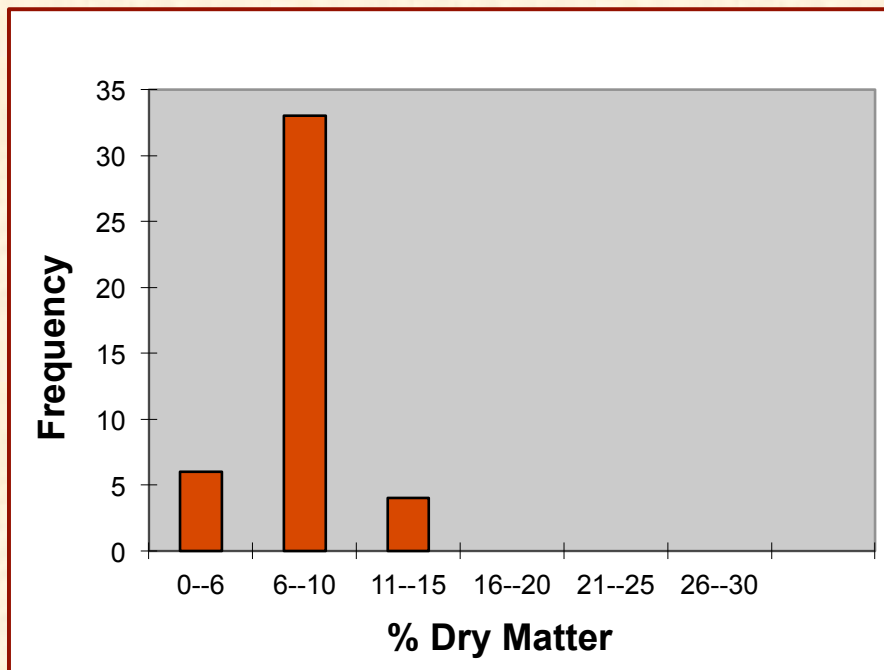
Vitamin Composition of Squash

Abbrev	Name	100 g	28 g	% Daily	
		Fruit	Seeds	Requirement	
		mg	mg	Fruit	Seeds
A	retinoic acid ^z	3		31	
C	ascorbic acid	15	0.50	18	<1
B ₁	thiamin	0.05	0.02	4	2
B ₂	riboflavin	0.04	0.04	3	3
B ₃	niacin	1.0	1.25	7	8
	folic acid	20 µg	16 ug	5	4
	pantothenic acid	3.5 µg	0.16	1	<1
E	a-tocopherol		1.3	0.16	14
2					

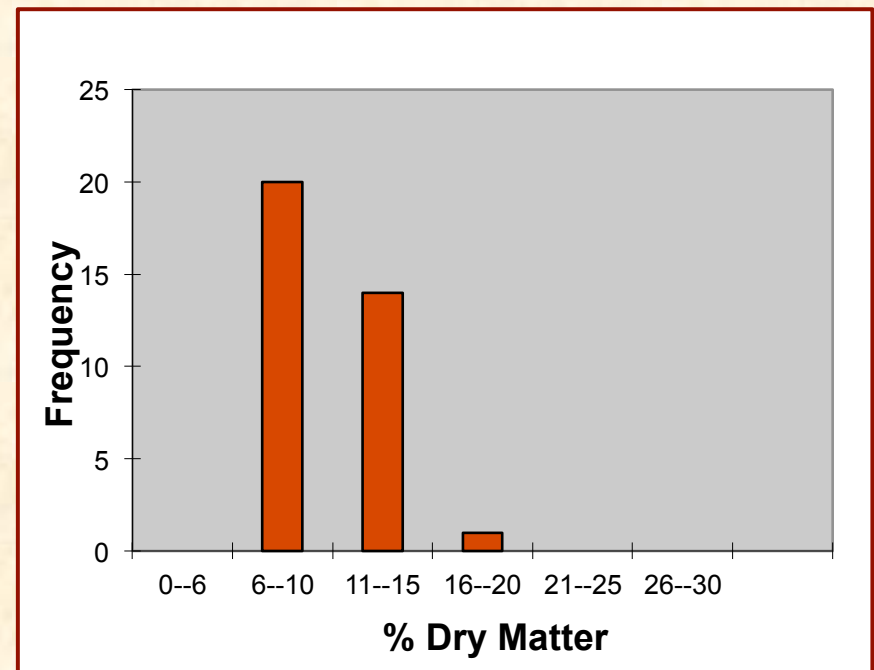
^zAmount of retinoic acid expected to be converted from 1.0 µg β-carotene

% DW Distribution in Pruned and Unpruned Plants of Autumn Delight

Unpruned



Pruned



Other Problems with Marketing Improved Eating Quality in Acorn Squash

1. Wholesale squash are often harvested immature.
2. Low dry matter is associated with higher fresh weight yields.
3. Most consumers are not aware of differences in eating quality in acorn squash.
4. Distributors and supermarket chains are not concerned with eating quality in acorn squash.

Ground Spot on a Mature Squash



Three Major Species of Winter Squash (*Cucurbita* species)



C. pepo

Acorn

Delicata

Sweet Dumpling

Sugar Dumpling

C. maxima

Buttercup/kabocha

Hubbard

Golden Delicious

Show pumpkins

C. moschata

Butternut

Dickinson Field

Large Cheese

Calabaza

Conclusions

- Eating quality in acorn squash can be markedly improved through breeding.
- Improved eating quality is not an easy sell to seed companies and wholesale growers
- Changes in grower and consumer preference for acorn squash will have to be instituted at the local farm outlets (CSA, farm stands, farmers markets).