



LEGUME CROP TESTING FOR SPACE

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Crop Production at Kennedy Space Center

- ❖ The food production team is evaluating a myriad of candidate crop species to deliver a highly nutritious and palatable component to the astronaut's diet in space crop systems.
- ❖ An evaluation of legumes was done at KSC for nutritional content, organoleptic acceptability, and microbiological quality, for eventual selection for space crop production.



Background

- A legume is a plant in the Fabaceae family and include species such as clover, alfalfa, tamarind, peanuts, chickpeas, peas, soybeans, and beans.
- Increase the number of crops that can be grown in small volumes in space under narrow band LEDs and elevated CO₂ (~3000 ppm)
- Can select crops that address nutritional deficits and meet crew acceptability



Materials and Methods

- Legume cultivars selected
- 3000 ppm CO₂, 50% Relative Humidity, 23°C, and PPF ~300μmol m⁻² s⁻¹
- Samples were harvested
- Nutritional analysis was conducted by commercial lab
- Samples were washed, packaged and shipped to Johnson Space Center Food Laboratory for sensory analysis



Legume Cultivars



Horticultural Findings

- Offered a good range of colors and textures
- Are shell peas worth the effort?



'Tom Thumb' shell pea

Nutritional Findings

Cultivar	Proximate Tests						Vitamin		
	Ash (%)	Calories (kcal/100 g)	Carbohydrates (Calculated-%)	Crude Fat (%)	Moisture (%)	Protein (%)	B1 (mg/100 g)	C (mg/100 g)	K (µg/g)
Royal Snap	0.82	67	11.86	0.31	82.7	4.31	0.107	9.94	0.18
Yellow Snap	0.67	48	8.45	0.19	87.5	3.19	0.113	11.6	0.16
Velour Purple	0.94	50	9.44	0.13	86.8	2.69	0.031	4.98	0.28
Bean '4921'	1.25	49	8.44	0.22	86.9	3.19	0.049	3.19	0.37
Antigua	1.11	42	6.67	0.23	88.8	3.19	0.029	2.89	0.23
ES Thick Pod 404-51-2	0.82	57	10.18	0.24	85.2	3.56	0.106	9.53	0.20
ES Thick Pod 404-51-2-1	0.85	69	12.55	0.30	82.3	4.00	0.109	7.27	0.21
Tom Thumb	1.10	113	18.92	0.44	71.1	8.44	0.187	7.03	0.27

- 2-8% protein by weight
- Purple and yellow types contained highest amount of Vit. B1 , shell pea contained the most
- Can provide Vit. C, up to 9.94 mg/100g
 - ~50mg/100g Vit C in oranges
 - Mature kale contains 3.9ug/g

Cultivar	Elemental Content					
	Ca (%)	Fe (%)	Mg (%)	P (%)	K (%)	S (%)
Royal Snap	0.081	0.0006	0.050	0.072	0.271	<0.02
Yellow Snap	0.067	0.0006	0.033	0.071	0.224	<0.02
Velour Purple	0.077	0.0009	0.039	0.068	0.340	0.02
Bean '4921'	0.074	0.0007	0.037	0.073	0.506	0.02
Antigua	0.058	0.0007	0.032	0.058	0.390	<0.02
ES Thick Pod 404-51-2	0.075	0.0008	0.040	0.080	0.283	<0.02
ES Thick Pod 404-51-2-1	0.073	0.0009	0.040	0.088	0.296	<0.02
Tom Thumb	0.023	0.0015	0.046	0.168	0.412	0.04

Sensory Findings

Cultivar	Attribute					
	Overall	Appearance	Color Intensity	Aroma	Flavor	Texture
Early Snap 404-51-2	8.06 ± 0.9	7.59 ± 1.3	8.25 ± 1.0	6.37 ± 1.6	8.59 ± 1.8	8.19 ± 1.0
Early Snap 404-51-2-1	8.03 ± 0.8	7.78 ± 1.3	8.06 ± 0.9	6.84 ± 1.6	8.19 ± 1.0	8.19 ± 1.0
Yellow Snap	7.26 ± 1.5	7.26 ± 2.0	6.93 ± 2.2	5.96 ± 1.4	7.37 ± 1.5	7.78 ± 1.5
Antigua	6.34 ± 1.9	7.25 ± 1.5	7.69 ± 1.2	6.03 ± 1.4	5.81 ± 2.1	6.97 ± 1.9
Royal Snap	6.34 ± 1.8	6.28 ± 2.2	6.31 ± 2.2	6.03 ± 1.4	6.06 ± 1.9	6.47 ± 1.9
4921 Bean	6.11 ± 1.6	7.11 ± 1.8	7.67 ± 1.4	5.67 ± 1.1	5.92 ± 1.9	6.89 ± 1.8
Tom Thumb	5.93 ± 2.2	7.07 ± 1.5	7.15 ± 1.5	5.59 ± 1.3	5.26 ± 2.4	7.04 ± 1.8
Velour Purple	5.52 ± 1.9	5.74 ± 2.2	5.74 ± 2.5	5.22 ± 1.5	5.07 ± 1.9	6.41 ± 2.2

Early Snaps

Pros

- Smelled and tasted just like cantaloupe
- Tender succulent leaves

Cons

- Too much stem

Yellow Snap

Pros

- Great savory, spicy kick.
- Will pair well with other leafy greens
- Great topper

Cons

- Too much stem

Cultivar	JAR Attributes				
	Crunchiness	Juiciness	Freshness	Sweetness	Bitterness
Early Snap 404-51-2	3.00 ± 0.4	3.06 ± 0.3	3.00	3.03 ± 0.6	3.63 ± 0.4
Early Snap 404-51-2-1	3.00 ± 0.3	3.06 ± 0.2	3.00 ± 0.3	2.97 ± 0.5	3.06 ± 0.4
Yellow Snap	3.07 ± 0.3	2.96 ± 0.4	2.96 ± 0.3	2.70 ± 0.5	3.18 ± 0.4
Antigua	3.00 ± 0.4	2.59 ± 0.6	2.94 ± 0.5	2.28 ± 0.8	3.75 ± 0.6
Royal Snap	2.66 ± 0.5	2.53 ± 0.7	2.81 ± 0.7	2.19 ± 0.6	3.34 ± 0.5
4921 Bean	2.96 ± 0.6	2.59 ± 0.7	2.96 ± 0.4	2.30 ± 0.7	3.63 ± 0.7
Tom Thumb	3.15 ± 0.4	2.67 ± 0.6	3.15 ± 0.7	2.19 ± 0.7	3.93 ± 0.7
Velour Purple	3.04 ± 0.6	2.44 ± 0.6	2.96 ± 0.8	2.19 ± 0.7	3.74 ± 0.9

Royal Snap

Pros

- Good texture

Cons

- Tasted of black licorice
- Soapy

Tom Thumb

Pros

- Enjoyed spicy flavor

Cons

- Yellow leaves
- Poor texture

Selected Taster Comments →

Velour Purple

Cons

- Mushy
- Too small

Conclusions

- Legumes grow reasonably well in mission relevant environmental conditions
 - Select legume can be grown in small, constrained volumes of space craft
 - Selected legumes are mostly palatable to tasters
 - If chosen and cultivated correctly, they have the ability to supplement substantial amounts of protein, vitamin C, B1, and K

